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A Framework to Support the Process of Measurement of Customer's Satisfaction According to ISO 9001

JOSE-AMELIO MEDINA-MERODIO¹, CARMEN DE-PABLOS-HEREDERO²,
LOURDES JIMENEZ-RODRIGUEZ¹, LUIS FERNANDEZ-SANZ¹,
RAFAEL ROBINA-RAMIREZ³, AND JOSE ANDRES-JIMENEZ¹

¹Computer Science Department, Polytechnic School, University of Alcalá, 28871 Alcalá de Henares, Spain

²Business Economic Department (Administration, Management and Organization), Applied Economics II and Fundamentals of Economic Analysis, Rey Juan Carlos University, 28032 Madrid, Spain

³Business and Sociology Department, University of Extremadura, 10071 Cáceres, Spain

Corresponding author: Jose-Amelio Medina-Merodio (josea.medina@uah.es)

ABSTRACT Each time more companies seek to differentiate themselves from their competitors. For this, they resort to company certification through standards such as ISO 9001 or EFQM. The quality norms permit business to improve process management and production and reduce the lack of knowledge. Therefore, the main objective of this research is to propose a framework to support the process of improving customer's satisfaction according to ISO 9001. To achieve the main objective, the methodology of the design science research process has been followed. First, the problems in the evaluation of customer's satisfaction required by ISO 9001 have been analysed. Second, an expert system has been developed to evaluate the process. To end, the system has been validated. The results suggest that this system facilitates continuous improvement in organizations, providing the customer's vision of the organization, and making possible the implementation of actions oriented to retain customers. This study presents important managerial implications. Insights from this research allow us to offer recommendations that can help practitioners and managers interested in the implementation of expert systems, to focus in quality processes that can increase the chances of a successful adoption.

INDEX TERMS Artificial intelligence, expert system, balanced scorecard, quality, processes, ISO 9001, EFQM.

I. INTRODUCTION

In a world of increasingly more globalized and competitive economies, reaching quality products and processes are one of the main strategies adopted by companies [1]. Porter considered that a product differentiated by quality and design ensures buyer loyalty. However, one that is poorly differentiated will allow substitutions of equal or low cost [2].

Besides, customer's satisfaction is one of the fundamental objectives of organizations today. Each time more, companies are improving in areas close to the customers such as quality and attention to the customer. In many cases, this is one of the reasons why firms often implement quality management systems. Firms are aware that a happy customer will be

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faithful, and conversely, a dissatisfied customer may involve indirect loss of more than 10 customers [3], [4].

Hill and Alexander [5], quantify the amount of customers that an average company loses between 10 and 30 each year. The problem is not just losing them, but knowing why customers decide to stop buying. To understand the reasons for customer's loss is essential to avoid future ones [6], [7].

Although this loss is irreparable, it is necessary to find a way to prevent the flow of customers to other competitors before it occurs. One possible way to do it, is to evaluate and know the degree of customer satisfaction that would prevent the customer loss [8].

To this end, standards such as ISO 9001:2015 [9] propose as a requirement the customer's satisfaction evaluation. For this reason, it is needed to know customers' opinion in order to meet present and future needs. Although earlier versions

of the 9001 standards defined the need for the measurement of customer's satisfaction, it is not until the release of ISO 9001:2008 [10] when the use of a questionnaire is shown in an explicitly way, as a way to evaluate customers' satisfaction.

It is for this reason and in order to guide the customer satisfaction evaluation process, that the Spanish Association for Standardization and Certification (AENOR) in 2005 proposed the Spanish Standard UNE 66176:2005 [11] as a guide for the measurement, monitoring and analysis of customer satisfaction. It has subsequently been replaced by Standard ISO 10004:2015 [12].

Also, in 2015, ISO 10002:2015 standard was published [13]. It intended to be a guide for the design and implementation of an effective process of complaints for all kinds of activities, commercial or not, including those related to electronic commerce.

Moreover, this type of standard helps companies reducing the loss of knowledge [14], due to the fact that an important feature based on the quality norms, such as the ISO 9001, shows this reality and recommends firms to document different processes and procedures. However, this is not enough since, in many cases, they are just recommendations.

The distribution of the business structure in the European Union EU-28 is made up of micro-companies (between 0 and 9 workers) that have gained prominence since they represent 93.1% of the total, small companies (between 10 and 49 workers); represent a 5.8% of the total, and medium-sized companies (between 50 and 249); represent 0.9% of the total. However, only 0.2% of the total are large companies (more than 250 workers) [15].

The implementation of a system to manage quality in the company is an important investment. In recent years, although there has been economic support from local and national administrations in Spain [16], [17], quality systems allowed maintaining the number of certificates, despite the serious economic crisis suffered in the last years. In 2018, the number of companies certified according to ISO9001 and ISO 14001 was around 32,000 and 13500 certificates respectively [18].

Apart from this, there is an increasing information and communication technology (ICT) integration in companies, although it is slow, since the use of ICT in Spanish companies is still low. The last report of June 2018 about the use of ICT in Spanish firms [16] includes a synthetic indicator that measures the digitization of companies in ten sectors and positions information and communication firms as the most digitized, both in the areas of small and medium-sized enterprises (SMEs) and large companies (52 points out of 100) and in the area of micro-enterprises too (34.7 points out of 100). In this report, there is a significant increase in areas such as cybersecurity, cloud computing and big data [19], [20].

This is because, as it happens with quality, an interesting implication coming from Administrations in all concerning with firm's motivation and development of information and communication technologies (ICT) has taken place in the last years. The Avanza Plan, The Avanza Plan 2 and the

Digital Agency for the development of the Information Society in Spain are good examples of these interests. One of main objectives of these initiatives is the implementation of business solutions based in the use of ICT in order to contribute to the increase of firm's competitiveness and productivity [21], [22].

In line with these data, various reports as Accenture [23] indicate that 70% of the top Spanish executives consider that they must use artificial intelligence (AI) to meet their growth objectives, but 76% affirm that they have difficulties to boost it. 66% of senior executives believe that if they do not scale AI in the next five years, they will be completely out of business.

The International companies obtained almost triple the return on their investments in AI. The report presented by Capgemini [24] indicates that 75% of companies that use artificial intelligence raised their income by 10%. Gartner's report [25] found that organizations surveyed are currently seeking AI solutions that can improve decision making and process automation.

According to O'Brien and Marakas [26] "An expert system (ES) is a knowledge-based information system that uses its knowledge about a specific, complex application area to act as an expert consultant to end users. Expert systems provide answers to questions in a very specific problem area by making humanlike inferences about knowledge contained in a specialized knowledge base".

In the context of manufacturing and management, Kumar [27] studied and analyzed the use of expert systems in different areas, and Koskela *et al.* [28] analyzed the role of knowledge engineering in information management on the stages project planning. In line with these analyses, we consider that expert system technology may considerably help and improve the performance and decision making process, as, on the one hand, it reduces the loss of knowledge and, on the other, it automates the processes which require expert decision made.

However, few studies have addressed its application in Quality Management System for measuring customer's satisfaction according to ISO 9001: 2015.

Therefore, the objective of this research is the analysis and improvement of the process of measurement of the satisfaction of customers of ISO 9001 through Expert Systems use in order to explore the degree of satisfaction with the service / product performed by the company and to know customers' needs to satisfy them.

According to that premises, the contribution of the paper is twofold. First, the process of measurement of the satisfaction of customers of ISO 9001 and the competitive advantage that it provides, is analysed. Second. the transformation of knowledge into rules for which the tasks of training and extraction of knowledge will take place and so the attenuation of the loss of knowledge with the use of artificial intelligence. Once customer's satisfaction has been evaluated, the firm will be able to take a series of decisions to meet their needs.

This paper is organized as follows: Section II presents the related work, section III describes the methodology, section

IV analyses and identifies the problem V presents the design and development of the artefact, section VI describes the validation and evaluation of the system, section VII presents the discussion and finally section VIII presents the conclusions.

II. RELATED WORK

A. ISO 9001

Quality has been one of the most important tools in all economic sectors, therefore the organizations have the need to be certified in quality standards to show that they comply with them.

The ISO 9001 norm is focused in the continuous improvement but as Ishikawa [29] indicates, a system of quality can only be improved if it is controlled with rational measures. This implies the need for measuring all the processes in the firm.

Thus, Casadesús *et al.* [30], Fonseca and Domingues [31] and Boira [32] indicate that the implementation of the ISO 9001 standard provides significant benefits to organizations. These benefits can be both internal benefits as improved product quality, better process performance, short delivery times, cost reductions, improved system documentation, higher quality awareness, and external benefits as improved customer satisfaction, better market image and stronger competitive position.

This was corroborated by Fonseca *et al.* [33]. They concluded that a Quality Management System (QMS) certification generates benefits for the certified organizations, it improves organizational competitiveness and success, by helping them to operate efficiently and respond to customer and key stakeholder requirements.

The first version of ISO 9001 was published in 1987. Since then, it has been used by organizations independent of the size and sector where they operate.

In 1994, the standard was updated and focused mainly on the product. This standard improved the clause on design and development control, by eliminating the ISO 9002 and ISO 9003 standards, unifying them in the following ISO 9001 version.

Already the 2000 version, became a standard for quality management and not quality control, by introducing the process approach. The 2008 version focused on the effectiveness of the quality management system in meeting customer requirements [34]. In 2015 the ISO 9001: 2015 [9] and ISO 14001: 2015 [12] were published. They propose a new common schema regarding its structure, that facilitates integration between the two standards and with other business activities.

The need to use the quality manual was removed. Records and documents were renamed “documented information”. The possibility of representing management in actions such as the participation of audits was also eliminated.

The concept of goods and services is introduced in a clear way. Until now it was focused on the product and the concept of interested party was started. Regarding communication, more explicit and detailed requirements are proposed for both internal and external communications.

The concept of preventive action is eliminated by focusing on corrective actions and the study of risk and opportunities were welcomed, as companies are asked to identify the context in which they operate.

The PDCA cycle (Plan-Do-Check-Act) and process approach were strengthened to increase the performance and efficiency of the processes through monitoring, measurement, analysis and evaluation methods.

The changes introduced consider the complete life cycle of the product or service during the evaluation of environmental aspects when considering purchases and communication, as well as providing greater emphasis on monitoring environmental performance [36], [38].

For Fonseca *et al.* [34] the benefits achieved by ISO 9001:2015 implementation focused in the adoption of risk based thinking, considered the major benefit to be realized; although it was the major difficulty to overcome. Other benefits were the alignment with other management systems, the increased top management commitment, the identification of risks and opportunities. The knowledge management was also reported as a significant benefit of ISO 9001:2015.

Likewise, Zimon and Dellana [38], consider that the main motivation for obtaining ISO 9001 certification was centred around market visibility and gaining new customers, rather than on lowering operating costs or improving quality and organization documentation.

Dellana and Kros [39] suggest that companies adopting ISO 9001 are likely doing so as part of an overall quality management program and by organizational position in the supply chain more so than from direct market pressure.

Also, Zimon and Zimon [40] analyzed the impact of an implementation of the quality management system according to ISO 9001 on the improvement of processes related to the management of liabilities to suppliers. The results confirm that more effective management of liabilities towards suppliers can be observed in enterprises applying appropriate system procedures.

Pantouvakis *et al.* [41] analysed the dimensionality of the ISO 9001 effectiveness. It was evaluated through the degree of achievement of the standard's objectives, as they are prevention of nonconformities, continuous improvement and customer satisfaction focus, which contribute to the performance of companies. Furthermore, it was observed that the product/service quality and operational performance of the service companies are directly and significantly influenced by ISO 9001 effectiveness.

Domingues *et al.* [42] suggest that the auditors' perceptions and experience regarding ISO 9001:2015 International Standard influence their judgment to assess ISO 9001:2015 QMSs within the certification process. Thus, the importance of selecting auditors with the appropriate ISO 9001:2015 knowledge and experience to ensure a credible and accountable certification process to all stakeholders involved, is key.

Sfreddo *et al.* [43] observed that the majority of the studies reviewed found a positive relation between ISO 9001

implementation and operational and market performances which indirectly will influence their economic-financial performance. Additionally, the development of actions to enhance the maturity of process management and develop process enhancement tools aligned to QMS can also positively influence the performance.

B. EXPERT SYSTEM IN QUALITY

Although, there is a large number and variety of publications on expert systems in general, few of them are focused on expert systems applied to quality.

These works focused on analysing the different areas as Statistical process control (SPC), Quality Assurance, Inspection and Sampling, Control of production and Design of experiments.

Therefore, a short description of the main background focused on the different solution of expert systems applied to quality from different points of view has been offered.

Gipe and Jasinski [44] carried out the development of an Expert System to solve problems in the quality systems, such as detection of significant variations in process output, diagnosis of out-of-control events using a rulebase, and analysis of undiagnosed out-of-control events by using additional process data or process knowledge.

Gipe and Jasinski [44] and Evans and Lindsay [45] developed an expert system in statistics applied to quality control. This system does not only select expertise in the control chart, but it rather offers interpretations of such graphs, providing conclusions on the control process.

Hosni and Elshennavy [46] developed a system for quality control based on knowledge, which is appropriate to specific inspection procedures by variables and for the selection of the control graphs.

Already in 1989 Pfeifer [47] published and described the success of the results of an expert system applied to the detection of defects during the production process in Germany. At the same time, Ntuen *et al.* [48] developed an expert system that, by applying pattern recognition, was able to inspect the manufacturing processes.

Lee *et al.* [49] reported the development of an expert system to evaluate the quality controls. For that, the method examines the effect of a large number of design factors on the variability of a product's response due to various sources of disturbance.

Another important expert system was developed by Crawford and Eyada [50] with the purpose of planning the allocation of resources for the quality assurance program which provides in advisories are given to the user regarding key purchased material receipt inspection strategies. Subsequently, Eyada [51] developed an expert system for the evaluation of procedures within the quality assurance audit, taking into account the process for suppliers and products.

Brink and Mahalingam [52] as cited by [53] developed an expert system that evaluates the quality of the level of production, which would allow us to detect and correct defects that occur during the production process.

Fard and Sabuncuoglu [54] analysed wasted time by quality control managers in routine and complex decision making in the production system. For their solution, an expert system was developed to facilitate the selection of an appropriate sampling plan for each case: Single, double or multiple.

Also, in 1990 Ohta and Kanagawa [55] proposed a project of sampling by attributes based on fuzzy logic. through the design of procedure for the single sampling attribute plan based on fuzzy sets theory.

Allen and Kathawala [56] summarize several current expert systems used in quality management and present a framework for choosing appropriate application candidates and a guide to integrate expert system technology into these applications. Following the framework will significantly improve the chances for a successful expert system implementation.

Apart from this, Rehbein *et al.* [57] present different applications in process industries and show several case studies that discuss the justification, development, and implementation of expert system's applications.

Paladini [58] published the development of an expert system for the evaluation of quality inspection which help with those decisions related to the preliminary activities for inspection development, determining of the need or convenience of carrying out the inspection or the level of this.

Liao *et al.* [59], proposed an expert advisory system for the ISO 9001 quality system in 2004. This expert advisory system integrated the ISO 9001 quality system guidelines and an evaluation approach based on the Malcolm Baldrige National Quality Award (MBNQA) criteria into a knowledge-based expert system providing assessment results and implementation suggestions to the organization.

Other development of an expert system was proposed by Reffat and Harkness [60] to evaluate the effects on environmental quality of proposed modifications to an office building following a post-occupancy evaluation.

Srikanth *et al.* [61] presented a formal view of AKD from the decision making perspectives and proposed an Intelligent Quality Management system expert with Post Analysis of Actionable Knowledge Discovery (PA-AKD for short) framework. In this system, the implementation process of quality discovery is mainly composed of quality knowledge base, primary quality database, method base and data mining module This was compared with the knowledge Base.

Other various works have been oriented to the control of production rather than to its management. As Liukkonen *et al.* [62] explained, the system exploits real production data and it can be used to diagnose and optimize the manufacturing processes.

Other works as Ling-Zhong [63] explain how expert systems have focused on the use of logic Fuzzy quality function deployment and entropy used to determine the intensity of criteria in trade shows to develop the fuzzy decision support system. The resulting fuzzy values can be used to analyse the variance and the importance of criteria in trade shows more effectively compared to the crisp values.

Lee *et al.* [64] in 2011, proposed an Expert System for auditing quality management systems in Construction (CQMA), in this case the Expert's rule base was constructed using information obtained from auditors of quality management system (QMS). CQMA Expert imports the quality requirements relative to the many quality management processes specified in ISO 9000, processes audit inputs, and generates consistent decisions relative to conformance to standards.

Behbahani *et al.* [53] propose the use of a knowledge based system (KBS) for statistical process control (SPC) to organize this knowledge area which has been obtained from the study of cases, case-based reasoning (CBR).

C. INFERENCE ENGINE

CoCoA [65] is a system that allows calculating commutative algebra. The core of the system is an implementation derived from the Buchberger's algorithm [66]. The algorithm has been optimized according to a group of directions and is used as a base for many operations [67], [68].

The logical and mathematical ideas presented in this section are based on [69]–[72] and the research on the application of Gröbner Bases to automated deduction [73], [74], which was applied to the study of medical appropriateness criteria [75], to the diagnosis of anorexia [76] to Alzheimer's Disease Diagnosis [77] and to other fields (railway interlocking systems) [74] and for diagnosis of care problem [78]. In addition, Pfalzgraf [79] developed a new approach formalized in an abbreviated theory. References [80], [81] are other related works.

III. RESEARCH METHODOLOGY

The design science research (DSR) is highly relevant to information systems (IS) research because it directly addresses two of the key issues of the discipline: The central role of the IS artefact and the importance of professional relevance of IS research.

The Design Science Research (DSR) paradigm has its roots in the sciences and engineering of the artificial. The model DSR is an adaptation of a computable design process model developed by Takeda *et al.* [82]. Even though the different phases in a design process and a design science research process are similar, the activities carried out within these phases are considerably different [83]. Both design science research and design [82] use abduction, deduction, and circumscription but, there is difference in how these cognitive processes are used.

Hevner and Chatterjee [84] proposed a set of principles for doing design science research. They established a set of quality attributes for designing products, emphasizing the technical quality of the device and the device to achieve the intended organizational purposes.

In this line, Baskerville *et al.* [85] have developed a set of evaluation criteria for DSR [86]. The evaluation should be formative in the early stages of the project what allows changes in the problem and in the nature of the artefact and,

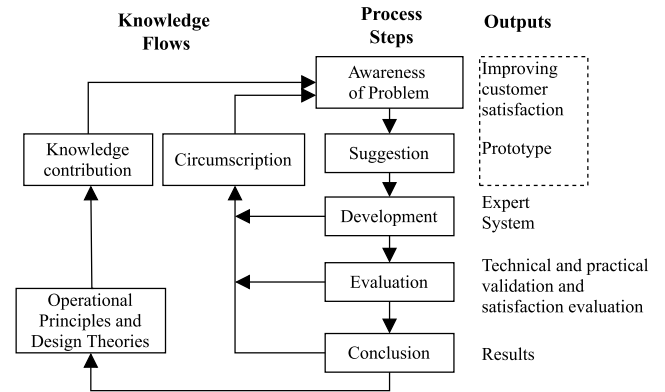


FIGURE 1. High level design science research process (adapted from [92]).

even if necessary, redirecting the design [87]. Besides, there should be summative assessments to assess the value and usefulness of results by the end of the project [88].

Hevner and Chatterjee [84] understand the notion of artefact in terms of “a construct, a model, a method, and/or an instantiation”. March and Smith [89] consider the Design Research strives to “create things that serve human purposes”. Besides it suggests that a feasible artefact is relevant to a context which can successfully address a problem. Peffers *et al.* [90] proposed to approach a methodology that provides a framework for performing DSR.

Hevner and Chatterjee [91] discuss several benefits in using the Design Research approach. They state that the goal of Design Research is utility as such and that the continuous building and evaluation of artefacts accomplish this.

Kuechler and Vaishnavi [92] have extended the general design cycle by reflecting on DSR purposes. All frameworks follow the high level pattern similar to shown in Figure 1. This process is iterative; it is repeated several times, where experience and knowledge from the last iteration flow back into the early steps of the process.

Thus, the framework of Vaishnavi and Kuechler [93] has been the choice for the realization of a research project.

Therefore, their proposed approach describes the design process in five steps.

In the first step (*Awareness of problem*), the researcher must identify the problem by consulting multiple sources including novel designs or the study of other reference disciplines, which provides the opportunity to find new fields of research. Based on the identified problem, a formal or informal proposal is made to initiate research. Section IV details the process followed to identify the problem that leads to the research proposal. Several data sources are consulted and detailed in section II (related works).

In the second step (*Suggestion*), based on the proposal, the researcher must propose a tentative design, which foresees a new functionality based on a novel configuration of new or existing elements. In the introduction it is stated that an expert system is the right artefact because of its simplicity,

and in Section V, before its development, a tentative design is proposed.

In the third step (*Development*) a tentative design is developed and implemented by selecting the most appropriate techniques to develop an artefact, being novel in the design and not in the construction of the artefact. The application itself can be very simple. Section V details the process that has been followed to implement the proposed system, providing a design and implementing it. The techniques that have been considered most appropriate for developing the model are identified and their construction is explained.

In the fourth step (*Evaluation*) the system is evaluated according to the criteria defined in the proposal, deviations from expectations are noted. The results of the evaluation phase and additional information obtained from the functioning of the artefact are fed back into another round of suggestions. If necessary, it is redesigned based on the deviations obtained. Section VI describes the steps taken to evaluate and validate the system by indicating the feedbacks made to improve the system.

Finally, it is the conclusion, which assesses the overall results of the design process and communicates the results. This is shown in section VIII (*conclusions*).

IV. AWARENESS AND IDENTIFICATION OF THE PROBLEM

As we have described, customer satisfaction is one of the most important requirements. In this aspect, the standard ISO 9001:2015 is clear, in clause 9 "Performance evaluation", more concretely, in clause 9.1.2. "Customer satisfaction" where it is indicated that a control on customer's satisfaction must be realized to analyse the results that allow obtaining a feedback of the input data.

To accomplish the requirements coming from this norm, most companies evaluate customer's satisfaction in two different ways: i) sending a questionnaire to a group of customers that will be analysed afterwards or ii) controlling their demands by using marketing policies.

Although both ways are interesting, we are going to be focused in the first option: Sending a questionnaire for analysing customer's satisfaction, as a prototype to evaluate customer's satisfaction according to the norm ISO 9001:2015 is being proposed in this research.

A. JUSTIFICATION OF THE QUESTIONNAIRE QUALITY

The questionnaire was defined according to requirement 9.1 "Monitoring, measurement, analysis and evaluation" more specifically the clause 9.1.2.: "Customer satisfaction". The objective of the questionnaires pursues modelling different aspects, not only with regard to user profiles but technical performance and quality processes.

Although the questionnaire could be very long and contain many questions, it is usual that questionnaires with more than one page are not answered. For this reason, only 12 questions have been defined, 10 of them are closed questions and 2 of them are opened questions. These opened questions will allow to contrast and check responses.

Each question has been raised in such a way that it helps to obtain each customer's opinion regarding with products and the most significant processes, as for example delivery times, delivery of material, etc. Therefore, the questionnaire comprises three groups of clearly defined questions. On the one hand, we have questions that allow us to evaluate what customers think of the products, the second group consists of questions related to the information and services offered by the company and a third group allows the company to evaluate and validate the response of customers through the global assessment of the company.

The closed questions present four possible answers: "Excellent", "Good", "Regular" and "Deficient"; their internal encoding in the database will be between "3" for "Excellent" and "0" for "Deficient".

So, the information received will allow the expert system to recommend different options to improve the customer's opinion about the company.

Once the questionnaire was prepared, it has been used to structure knowledge. To do this, a general class called "Customer Satisfaction" was defined. This class includes three groups (called "private classes"): "Measurement of satisfaction on the product", "Measurement of satisfaction on the information and service offered" and "Measurement and verification of general satisfaction".

Each private class has a "subclass" with the exception of "Measuring satisfaction with the information and the service offered" which has two subclasses "Satisfaction with the information and the service offered" and "resolution of complaints and incidents".

Each of these subclasses contains what it has been called "concrete elements" to be able to implement it in the expert system. This structure will allow to implement the set of rules that were introduced in the inference engine.

After the identification and motivation of the problem presented in the previous section of this research and after the consultation of a series of sources, both industrial and academic in the section, a design that allows reaching and verifying the contribution objectives is suggested.

V. DESIGN AND DEVELOPMENT OF THE ARTEFACT

A. SYSTEM ARCHITECTURE

1) INTEGRATION AND INTERCONNECTION BETWEEN SYSTEMS

The process for sending questionnaires was performed through web page, although the degree of ICT penetration in companies is increasing, there are companies that prefer using the fax or email due to lack of trust or lack of awareness. Therefore, the option of an email or fax has also been contemplated.

Then, the building of the system has been done according to two different points of view: One comes from the internal application's perspective by using a local database or a network and second, the connection is developed via Web, as it is shown in Figure 2.

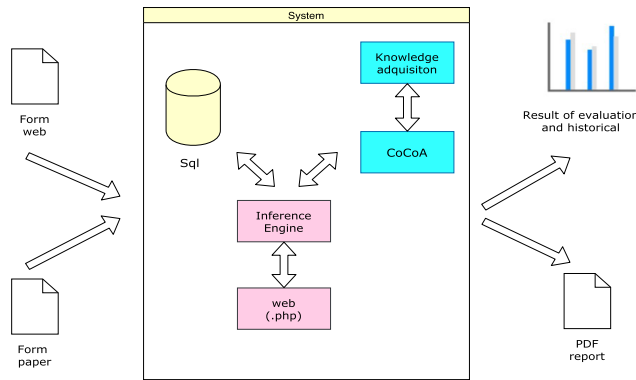


FIGURE 2. Blocks related to the expert system and the interconnection system.

The expert system was developed in order to be integrated with the rest of the tools that generally exist in any company, such as the Enterprise Resource Planning (ERP) system or the Customer Relationship Management (CRM) system. SQL Server has been used as system for data storage, regardless of the interface. This implementation will allow obtaining and displaying some data as internal resources, finance and human resources can be obtained, among others.

The information collected by using any of the means is afterwards processed and warehoused in a database system, in our case, the MySQL. For architecture, Java was decided to be used as the language of application development and, for the development of the knowledge system or expert system, the CoCoA (Computations in Commutative Algebra) system has been used as it is shown in subsection IV. D. It will allow analysing data by using an expert system based on rules and it will serve to assess the different actions to perform for each customer. It will also allow detecting incoherent areas in the introduction of data.

An important part of the system is the representation of the information. For this, a balanced scorecard (BSC) based on the development proposed for the British Airways Company at Heathrow [94] has been designed. The purpose of this was to show the most relevant data to the company's management and to the employees, offering them a general idea on the degree of customer's satisfaction with the company.

B. SYSTEM OPERATION

Data coming from the ERP system (Enterprise Resource Planning) are automatically introduced in the system. A frequent update to provide data takes place. The access to the database system can vary according to the connection system. If it is a local one, the user goes inside the general menu by using the user and password warehoused in the database system. In case the connection is via the firm's web, there will be an answering sheet located in the upper part of the web page so that the customer can fill in the validation data and access to the questionnaire to answer the questions.

From the main menu in the application, we can access to the main screen to represent the data by clicking the bottom

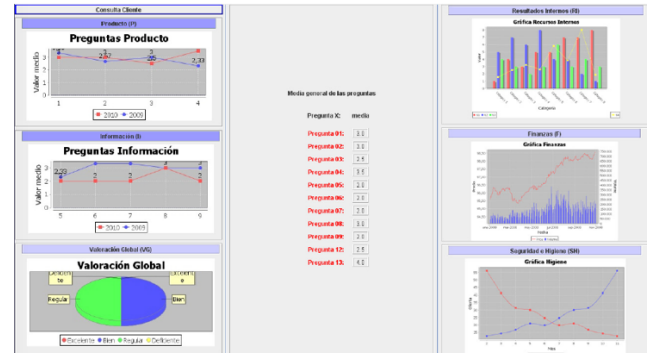


FIGURE 3. Main screen of data presentation (Spanish version).

“results”; A summary containing the received all customers' data is provided, as it is shown in Figure 3.

As it can be seen, the screen is composed of three different areas. On the left, the global information derived by customer's answers is shown. The central part presents the evolution of the data according to the mean of all the received questionnaires, although these values can be modified by the administrator. On the right, this area shows the acquired data from the firm's integral systems as Enterprise Resource Planning (ERP) or Customer Relationship Management systems (CRM) and that complements the information coming from the data of surveys about the customer's satisfaction. In this case, this area represents three main groups, Human Resources, Finance and Learning and growing (Security and Health Information). Above these graphics and clicking the mouse, another application form is shown. It offers the information by comparing data with the information obtained in previous years.

Once the survey has been accomplished, we can access the individual application form, in which the answers to the ten questions and the mean in comparison with the rest of firms are offered.

Based on the data obtained from the individual questionnaire of each customer, the expert system proposes individual actions that allow it to increase satisfaction and facilitate the company's decision-making for that client. It is shown at bottom right of Figure 4.

C. IMPLEMENTATION OF THE EXPERT SYSTEM

A Rule Based Expert System (RBES) usually has two components: a “Knowledge base” and an “inference engine” [77]. In this article, the knowledge base and the inference engine are, respectively, symbolically expressed and symbolically implemented using the computer algebra language CoCoA [65].

One of the difficulties we found was the interconnection of the database system with CoCoA, since these systems do not allow a direct connection. In our case, data have been extracted to text files, opened and processed inside CoCoA by obtaining a final report sent to a text file.

To increase the speed of the calculation of CoCoA, the analysis of the answers was carried out in two phases:

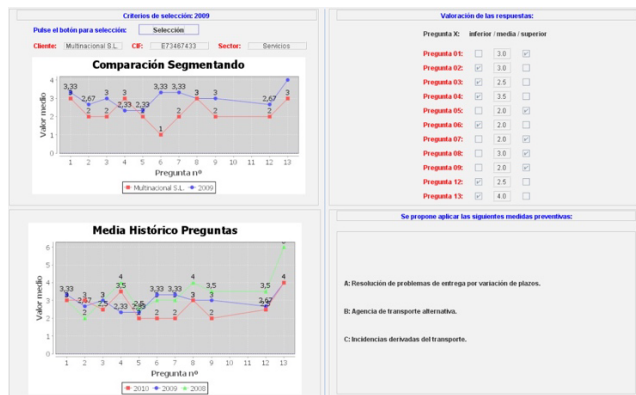


FIGURE 4. Screen to show the individual information of each company (Spanish version).

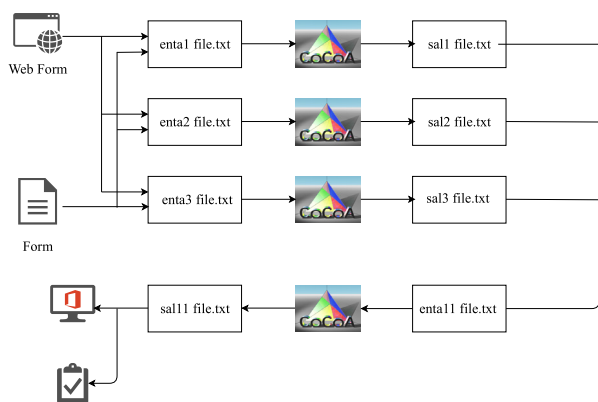


FIGURE 5. Connection model.

A first stage in a parallel and independent way, so as to evaluate the results of the questions by interest groups. This phase is composed by three group: A first group containing information of product, a second, with general information of the firm; and the third, which offers global information.

Once the calculations have been completed in the intermediate phase, the processing of the last phase begins. The results obtained have been processed. All this process applies the files shown in Figure 5.

For the performance of the information system, the help of a human expert in the area we are working in has been required. This knowledge has offered us the opportunity to define the variables and afterwards, they have been converted into logical rules by using Karnaugh's tables that have been implemented in the CoCoA system. This Rule Based Expert System (RBES) has been named ESASQ "Expert System for Analysing the Satisfaction of Quality".

D. CONSTRUCTION OF THE MODEL

As proposed in the ISO 9001 model where customer satisfaction is the benchmark for a good business management, a series of questions to assess their degree of satisfaction have been raised.

As it has been argued in subsection IV. A, the model consists in a general class which is called "Customers Satisfaction". This class includes three groups (which are called "particular classes") that are "Measuring satisfaction about the product", "Measuring satisfaction about the information and service offered" and "Overall satisfaction measurement and checking".

Each particular class has "subclass" with the exception of "Measuring satisfaction about the information and service offered" which has two subclasses "Satisfaction with the information and service offered" and "resolution of complaints and incidents".

Each of these subclasses contains what it has been called "concrete elements".

The general class is composed by 10 closed questions and each one presents 4 variables, what represents 40 variables: x[1] to x[10]. Each variable has 2 possible states. This allows us to assess the degree of intensity. The question 11 that presents multiple options and the question 12 is an opened question, although they have not been used in the RBES.

Once the relation between classes, subclasses and concrete elements has been analysed, those relations have been translated into production rules to provide an assessment for each component and final assessment.

Following, we will proceed to perform the development of each of the classes and subclasses indicated.

1) DETECTION MEASURING SATISFACTION ABOUT THE PRODUCT

The particular class "Measuring Satisfaction about the products" when affects the product is composed by 4 variables (x1 to x4). See below box detailed.

- Question of measuring Satisfaction about the product
- x[1]: Compliance deadlines
- x[2]: Product Quality
- x[3]: Ratio Quality/price
- x[4]: State of delivered product

This question presents an indirect relationship with the degree of customers' satisfaction about the product received.

"Measuring Satisfaction with the information and service offered" evaluates the degree of customer's satisfaction. It provides us with information on the level of information received about product and services, the responding capacity to inquiries and incidents, the performance of salespeople.

The "Measuring of Satisfaction with the information and service offered" is divided into the subclasses: "Measuring of Satisfaction with the information" and "Resolution of complaints and incidents".

The subclasses: "Measuring of Satisfaction with the information" are composed by 4 variables (x5, x7, x8 and x9).

The subclasses "Resolution of complaints and incidents" are composed by the variable x[6]. It is related to the type of relationship that the customer has with business and how complaints or incidents have been solved.

- Question of measuring Satisfaction with the information and service offered

- Measuring of Satisfaction with the information
- x[5]: level of information received about products and services
- x[7]: responding capacity to inquiries
- x[8]: the performance of salespeople
- x[9]: assessment website
- Resolution of complaints and incidents
- x[6]: resolution of complaints and incidents
- Finally, "Overall satisfaction measurement and checking" allows us to corroborate the existence of possible real presence of problems and to avoid possible loses of future customers. It is divided in the following subclasses: Overall satisfaction measurement and checking and potential competition.
 - Question of overall satisfaction measurement and control
 - x[10]: overall valuation
 - Potential competition
 - x[11]: aspects to improve
 - x[12]: different competitors

2) TRANSCRIPTION MODEL INFORMATION INTO RULES

The extraction of knowledge has been obtained in two different ways. On the one hand, it was obtained by analysing the 9001 standard and on the other hand, it was the extraction through a quality manager to developing implementations, customer satisfaction analysis and compliance audits with the standard of quality management systems.

This process is similar for all classes, so the implementation of the class "Measurement of product satisfaction" is shown as an example.

The class "Measuring of Satisfaction with the product" presents four positive variables x[1], ..., x[4] and their negations $\neg x[1], \dots, \neg x[4]$. We should take into account that both a variable, as x[2] and its negation $\neg x[2]$, are known as "literals" and that literals as x[2] and $\neg x[2]$ are called "contrary literals".

The reason for considering these two literals aside the others is to simplify the tables, thereby we have 24 combinations, with the 16 literals as these x[1], $\neg x[1], \dots, x[4], \neg x[4]$ we can write 16 conjunctions like:

$$x[1] \wedge x[2] \wedge x[3] \wedge x[4]$$

The literals and their contrary literals never should appear in these conjunctions together, because this would lead to a contradiction.

Apart from this, each question can be represented by four possible values. For example, we will take question 2. This issue can take 4 possible states which are: x[2a], x[2b], x[2c], x[2d] that determine the value of the final variable x[2].

The model assigns a "Product Quality" (the variables "c[i]" with, denote four possible intensities) to each of these conjunctions. These intensities are:

- Intensities c[0]: Null c[1]: Low c[2]: Medium c[3]: High

This table shows how to obtain the value of the output of the analysis of the question 2.

Suppose that the model suggests the following relation: "IF the customer thinks than Product Quality is Excellent" = no AND "Product Quality is good" = yes AND "Product

TABLE 1. Product quality.

Intensities of "Product Quality"	x[2c] \wedge x[2d]	$\neg x[2c] \wedge x[2d]$	x[2c] $\wedge \neg x[2d]$	$\neg x[2c] \wedge \neg x[2d]$
x[2a] \wedge x[2b]	c[3]	c[3]	c[2]	c[1]
x[2a] $\wedge \neg x[2b]$	c[3]	c[3]	c[2]	c[1]
$\neg x[2a] \wedge x[2b]$	c[3]	c[3]	c[2]	c[0]
$\neg x[2a] \wedge \neg x[2b]$	c[3]	c[3]	c[2]	c[0]

Quality is regular = no" AND "Product Quality is bad" = no, THEN "the customer thinks that Product Quality is good". The production rule that translates is denoted as "R", is:

$$R : x[2a] \wedge x[2b] \wedge x[2c] \wedge x[2d] \rightarrow s2$$

It needs to be emphasized that the process of assignation of intensities for all Factors is the RBES, this assignation is not done at random, but based on the relations defined on the model.

Because of its complexity, it should be convenient entering into the details of the process. The description of classes will be offered, subclasses and concrete elements listed and described above, the establishment of relationship among conjunctions of concrete elements is done by a "weight procedure" in three steps:

- Skill of quality step: Based on the expert's opinion.
- Quantitative step: Calculated through the sum of the operative concepts to be considered.
- Correction step: Achieved from a consensus when steps one and two did not fit in.

An example, the subclass "Product Quality" has been used, which contains one subclass that gives high intensity. Classes as the particular class "Measuring of Satisfaction with the product" which contains four subclasses, giving rise to three types of intensities must be processed as follows. First, each subclass is processed as "Product Quality" by, obtaining this way, four intensities levels, which have, respectively, been denoted by the variables a[i], b[i], c[i] and d[i], with $i = 0, \dots, 3$. This process provides us the intensity level which will call "first level intensities" of each subclass.

So, it considers each subclass as a variable which belonged to the same class and it was assigned to each variable a percentage in the class it belonged, depending on the number of subclasses of the class.

The class "Measuring of Satisfaction with the product" has four subclasses: Compliance deadlines, product quality, ratio Quality/Price and state of delivered products. The same percentage was assigned to each subclass, as it is shown in Table 2. Second, from the first level intensities, in Table 3, it is shown the outputs a "second level intensity", here denoted by the variable s[i] ($i = 0, \dots, 3$).

In Table 3 the intensities are added and fixed to the values they can get (0, 1, 2, 3) and therefore the "second level intensities" that correspond to the class "Measuring Satisfaction with the product" are obtained.

It needs to be said again, that the assignation of the second level intensities s[i] to conjunctions of first level intensities a[i], b[i], c[i] and d[i], is not done in a random way, it is

TABLE 2. Measuring of satisfaction with the product.

Compliance deadlines				
Intensity Degree	Intensity	Code	Degree to add	Percentage
0	Null	x[1a]	0.0	
1	Low	x[1b]	0.3	25 %
2	Medium	x[1c]	0.7	
3	High	x[1d]	1.0	
Product Quality				
Intensity Degree	Intensity	Code	Degree to add	Percentage
0	Null	x[2a]	0.0	
1	Low	x[2b]	0.3	25 %
2	Medium	x[2c]	0.7	
3	High	x[2d]	1.0	
Ratio Quality/Price				
Intensity Degree	Intensity	Code	Degree to add	Percentage
0	Null	x[3a]	0.0	
1	Low	x[3b]	0.3	25 %
2	Medium	x[3c]	0.7	
3	High	x[3d]	1.0	
State of delivered products				
Intensity Degree	Intensity	Code	Degree to add	Percentage
0	Null	c[4a]	0.0	
1	Low	c[4b]	0.3	25 %
2	Medium	c[4c]	0.7	
3	High	c[4d]	1.0	

TABLE 3. Measuring of satisfaction with the product.

Intensities of Signs and Symptoms	x[2d]		x[4a]		x[2c]		x[2b]		x[2a]	
	x[4d]	x[4c]	x[4b]	x[4a]	x[4d]	x[4c]	x[4b]	x[4a]	x[4d]	x[4c]
x[1d]	x[3d]	s[4]	s[3]	s[3]	s[3]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3c]	s[4]	s[3]	s[3]	s[3]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3b]	s[3]	s[3]	s[2]	s[2]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3a]	s[3]	s[3]	s[2]	s[2]	s[3]	s[2]	s[2]	s[1]	s[1]
x[1c]	x[3d]	s[4]	s[3]	s[3]	s[3]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3c]	s[3]	s[3]	s[3]	s[3]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3b]	s[3]	s[3]	s[2]	s[2]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3a]	s[3]	s[2]	s[2]	s[1]	s[2]	s[2]	s[2]	s[1]	s[1]
x[1b]	x[3d]	s[3]	s[3]	s[2]	s[2]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3c]	s[3]	s[3]	s[2]	s[2]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3b]	s[2]	s[2]	s[2]	s[1]	s[2]	s[2]	s[2]	s[1]	s[1]
	x[3a]	s[2]	s[2]	s[1]	s[1]	s[2]	s[1]	s[1]	s[0]	s[0]
x[1a]	x[3d]	s[3]	s[3]	s[2]	s[2]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3c]	s[3]	s[3]	s[2]	s[2]	s[3]	s[3]	s[3]	s[2]	s[2]
	x[3b]	s[2]	s[2]	s[1]	s[1]	s[2]	s[1]	s[1]	s[0]	s[0]
	x[3a]	s[2]	s[1]	s[1]	s[1]	s[1]	s[0]	s[0]	s[0]	s[0]

done by introducing into the model a “percentage production procedure”, which is standardized for the highest intensity.

Which means that IF the first level intensity for Compliance deadlines is a[3] (high) AND the first level intensity for Product Quality is b[3] (high) AND the first level intensity for ratio Quality/Price is c[3] (high) AND the first level intensity for state of delivered products is d[3] (high) THEN the second level intensity for the class “Measuring of Satisfaction with the products” is s[3] (high).

This is done with the different factors as “Measuring with the information and service offered” and “Overall measurement and control”. It allows us to obtain the information of the customer, so we can take decisions, which facilitates loyalty of the customers and improve their satisfaction.

The output data are represented in a panel serving information to the steering and facilitating decision making and even providing a personalized customer loyalty plan.

E. CoCoA IMPLEMENTATION

In this studio, an example of CoCoA implementation is presented, so we only show the implementation of

“Measuring Satisfaction with the product” and get its intensity. The processing of other classes and subclasses of the model is similar; moreover, the production rules corresponding to first level intensities must be written down but, also, those corresponding to other levels intensities.

CoCoA requires having the logical formulae written in prefix form.

Next, the program’s commands appear inside borders, while explanations, which are not part of the program, are written in normal text.

The polynomial ring with coefficients in Z2 and in the 16 variables corresponding to the 4 subclasses which are Compliance deadlines, Product Quality, ratio Quality/Price and state of delivered products, each of them can take 4 level intensities and the ideal I are declared first:

```

- Definition of ring
A ::= Z/(2)[x[0, ..., 15], s[0..3]];
USE A;
- Definition of base Ideal
MEMORY.I: = Ideal(a[3]^2 - a[3], a[2]^2 - a[2], a[1]^2 - a[1], b[0]^2 - b[0], b[3]^2 - b[3], b[2]^2 - b[2], b[1]^2 - b[1], b[0]^2 - b[0], c[3]^2 - c[3], c[2]^2 - c[2], c[1]^2 - c[1], c[0]^2 - c[0], d[3]^2 - d[3], d[2]^2 - d[2], d[1]^2 - d[1], d[0]^2 - d[0], s[0]^2 - s[0], s[1]^2 - s[1], s[2]^2 - s[2], s[3]^2 - s[3]);
    
```

The polynomial translation of the bivalued logical formulae is done from the following instructions: NEG, OR1, AND1 and IMP, which correspond to the symbols \wedge , \vee , \neg , \rightarrow (we write OR1 and AND1 because OR and are particular CoCoA items which have a different use).

```

- Definition of the connective of the classic logic
NEG(M): = NF(1+M, MEMORY.I);
O(M,N): = NF(M+N+M*N, MEMORY.I);
Y(M,N): = NF(M*N, MEMORY.I);
IMP(M,N): = NF(1+M+M*N, MEMORY.I);
    
```

Next, production rules R1 to R256 (in prefix form) potential facts (F) are introduced.

```

- Definition of rules
R1: = NF(IMP(Y(Y(a[0],b[0]),c[0]),d[0]),s[0]), MEMORY.I);
R18: = NF(IMP(Y(Y(Y(a[0],b[0]),c[1]),d[1]),s[0]), MEMORY.I);
.....
R256: = NF(IMP(Y(Y(Y(a[3],b[3]),c[3]),d[3]),s[3]), MEMORY.I);
    
```

```

- Statement of Potential Facts
H1: = a[0]; H1N: = NEG(a[0]); H2: = a[1]; H2N: = NEG(a[1]); H3: = a[2]; H3N: = NEG(a[2]); H4: = a[3]; H3N: = NEG(a[3]); H5: = b[0]; H5N: = NEG(b[0]); H6: = b[1]; H6N: = NEG(b[1]); H7: = b[2]; H7N: = NEG(b[2]); H8: = b[3]; H8N: = NEG(b[3]); H9: = c[0]; H9N: = NEG(c[0]); H10: = c[1]; H10N: = NEG(c[1]); H11: = c[2]; H11N: = NEG(c[2]); H12: = c[3]; H12N: = NEG(c[3]); H13: = d[0]; H13N: = NEG(d[0]); H14: = d[1]; H14N: = NEG(d[1]); H15: = d[2]; H15N: = NEG(d[2]); H16: = d[3]; H16N: = NEG(d[3]);
    
```

F. VERIFICATION OF SYSTEM

The verification is done as follows:

Define the ideal J generated by the negations (recall that the theory requires dealing with negations, denoted "NEG", of formulae) of the 256 production rules:

– Ideal J of rules

$J := \text{Ideal}(\text{NEG}(\text{R1}), \text{NEG}(\text{R2}), \text{NEG}(\text{R3}), \text{NEG}(\text{R4}), \text{NEG}(\text{R5}), \text{NEG}(\text{R6}), \text{NEG}(\text{R7}), \text{NEG}(\text{R8}), \dots, \text{NEG}(\text{R254}), \text{NEG}(\text{R255}), \text{NEG}(\text{R256}));$

Define the three ideals generated by the negation of the potential facts in, respectively, the sets $K1$, and $K3$ above. NEG is, as required by the theory, applied to all facts and ought not to be mistaken with the "N" that appears in, for instance "H2N", which means that the corresponding customers has not the determining factor denoted by H2.

$K1 := \text{Ideal}(\text{NEG}(\text{H1}), \text{NEG}(\text{H2}), \text{NEG}(\text{H3}), \text{NEG}(\text{H4}), \text{NEG}(\text{H5}), \text{NEG}(\text{H6}), \text{NEG}(\text{H7}), \text{NEG}(\text{H8}), \text{NEG}(\text{H9}), \text{NEG}(\text{H10}), \text{NEG}(\text{H11}), \text{NEG}(\text{H12}), \text{NEG}(\text{H13}), \text{NEG}(\text{H14}), \text{NEG}(\text{H15}), \text{NEG}(\text{H16}));$

$K3 := \text{Ideal}(\text{NEG}(\text{H1}), \text{NEG}(\text{H2}), \text{NEG}(\text{H3}), \text{NEG}(\text{H4}), \text{NEG}(\text{H5}), \text{NEG}(\text{H6}), \text{NEG}(\text{H7}), \text{NEG}(\text{H8}), \text{NEG}(\text{H9}), \text{NEG}(\text{H10}), \text{NEG}(\text{H11}), \text{NEG}(\text{H12}), \text{NEG}(\text{H13}), \text{NEG}(\text{H14}), \text{NEG}(\text{H15}), \text{NEG}(\text{H16}));$

Recall that inconsistency exists when the Gröbner base of the ideal. $I+J+K$ is (1).

$\text{ReducedGBasis}(\text{MEMORY.I}+K1+J);$

$\text{ReducedGBasis}(\text{MEMORY.I}+K3+J);$

As it is not the output for any of these three commands, the three parts of the Knowledge-based systems considered are consistent.

Regarding extraction of knowledge from the Knowledge-based systems, whether or not a formulae (here, we have four formulae to check: $s[3]$ the Satisfaction with the product is high, $s[2]$ medium, $s[1]$ low, $s[0]$ null) is tautological consequence of (all) production rules and a maximal consistent set of potential facts that characterize the customers' satisfaction, can be deduced through the calculation of the normal form of the negation of the formula, module the ideal $I+J+K1$ (or $K3$).

For the ideal $K1$, a HIGH intensity is obtained.

$\text{NF}(\text{NEG}(s[0]), \text{MEMORY.I}+K1+J);$

$\text{NF}(\text{NEG}(s[1]), \text{MEMORY.I}+K1+J);$

$\text{NF}(\text{NEG}(s[2]), \text{MEMORY.I}+K1+J);$

$\text{NF}(\text{NEG}(s[3]), \text{MEMORY.I}+K1+J);$

$s[0]+1;$

$s[1]+1;$

$s[2]+1;$

0

For the ideal $K3$, a medium intensity is obtained:

$\text{NF}(\text{NEG}(s[0]), \text{MEMORY.I}+K3+J);$

$\text{NF}(\text{NEG}(s[1]), \text{MEMORY.I}+K3+J);$

$\text{NF}(\text{NEG}(s[2]), \text{MEMORY.I}+K3+J);$

$\text{NF}(\text{NEG}(s[3]), \text{MEMORY.I}+K3+J);$

$s[0]+1;$

$s[1]+1;$

0

$s[3]+1;$

VI. VALIDATION AND EVALUATION

The validation is one of the most important phases aimed to verify that ESASQ meets the purpose for which it was defined.

Three types of validations have been carried out, next both are detailed:

1) Technical Validation:

It has been verified that the obtained results through the GUI are consistent with the theoretical results in each one of the different phases defined in the model and implemented in the System. This validation has been carried out mainly, by the research group that has developed and implemented ESASQ.

The obtained results, as well as the explanations offered by the System, are analysed. As the subjectivity affects to the validation of any system, it has been necessary to count on with a team of experts, unconnected with our research group, so that they could validate it.

2) Practical Validation:

This validation was made in two levels:

- System understanding: The way of making questions about the variables as well as the diagnosis messages was analysed and improved. The obtained results, as well as the explanations offered by the System, are analysed. As the subjectivity affects to the validation of any system, it has been necessary to count on with a quality expert, unconnected with our research group, so that they could validate it.
- Quality: The results that ESASQ offers have been compared in two steps:

a) Step 1: In the presence of a determined real case which has been previously valued. The variables are introduced in ESASQ and some values or intensities are obtained, as it has already been explained. Then, the obtained values are considered as the standard for that case.

b) Step 2: Later, the Quality expert modifies some variables according to his/her criterion, either making worse the situation or improving it, by modifying a variable or modifying several of them. So, the Quality expert verifies if the intensities degrees that ESASQ shows correspond with his/her professional experience. To carry out the practical validation, a quality expert with more than 10 years' experience in the implementation of ISO 9001 quality management systems was counted on.

TABLE 4. ES perception of satisfaction, usability and accessibility.

Answers 1-5 (1 worst, 5 best)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
User 1	5	4	4	5	5	4	5	5	5	5
User 2	4	5	5	5	5	5	4	5	4	4
User 3	4	5	5	5	5	4	4	5	5	4
User 4	3	4	4	4	4	5	4	4	5	5
User 5	5	5	5	5	5	4	5	5	4	4
User 6	5	5	5	5	5	4	4	5	5	4
User 7	5	4	4	5	4	5	5	5	5	5
User 8	5	5	5	5	4	5	4	5	5	4
User 9	4	5	4	4	5	5	4	4	4	4
User 10	5	5	5	5	5	5	5	5	5	5
Mean	4,5	4,7	4,6	4,8	4,7	4,6	4,4	4,8	4,7	4,4

3) *Satisfaction With the Developed Application:*

For this, the user's satisfaction is analysed regarding the perception of satisfaction, handling, security, questions legibility, usability and accessibility of the RBES. The opinion was collected from other additional ten users with a questionnaire of 10 questions to evaluate with a 5-point Likert scale for responses [95].

Respondents were experts working in with the standards under study. So, the main requisite for respondents was the experience in ranging from 1-5 years in the quality area.

The following questions have been performed:

Q1 Degree of satisfaction with the application

Q2 Degree of efficiency provided by the application

Q3 Degree of the question's legibility

Q4 Degree of usefulness of the application. If it facilitates the use and control

Q5 Overall assessment of the application

Q6 The perception of use of SE applications to make work easier and motivates

Q7 Usability: Interoperability with the interface

Q8 Usability: Transitions among the different screens

Q9 Degree of accessibility of information.

Q10 Data entry and validation of the system

Table 4 represents the questions and results obtained.

The degree of satisfaction with the application reached 4.5, the degree of efficiency provided by the application scored 4.7 and the degree of the question's legibility was 4.6.

The question on the usefulness of the proposed ES to facilitate the use and control reached 4.8. and the overall assessment of the application was 4.7. Besides, the perception of use of SE applications to make work easier and motivate was 4.6.

We also included two questions referred to usability: Average score for operability of interface was 4.4 while transitions among the different screens reached a value of 4.8. Finally, questions on accessibility of information was 4.7 and data entry and validation the system averaged 4.4.

As feedback steps in the construction and implementation of the system as well as of the development of its interface, it was essential to make the validation of ESASQ with the purpose of verifying its effectiveness with respect to the raised objectives.

Due to this feedback obtained through the validation of the System, different modifications have been made, which made a better system possible. After each validation, it has been verified that the system improved its results with respect to the expected requirements.

VII. DISCUSSION

The research finding echoes with the benefits of ISO 9001 certification and implementation and the factors that affect the efficiency of performance in the organization, is that, continuous improvement is, the focus on customer satisfaction and the prevention of non-conformities, such as the effects about operational and market and financial performances; as well as the use of expert systems, emphasizing its use in areas of quality for firm performance improvement and efficiency of processes.

As indicated by Pantouvakis *et al.* [41] the implementation of the ISO 9001 standard has been an important research subject for many years now, since there are many unexplored topics regarding the optimization and contribution of the QMS. It is here where our tool contributes to the management and optimization of the customer satisfaction.

To do this research, the international management standards ISO 9001 were studied as well as their requirements, benefits and factors related as performance and the academic literature. Firstly, we studied the work about certification and implementation of ISO 9001, benefits and factors that impact on performance of companies or organizations.

Secondly, we studied the different expert systems applied to quality. Thirdly, we considered different researchers about the implementation of inference engine.

Due to an increasing trend for businesses all over the world to adopt standards of management practices, especially in small and medium-sized enterprises, the results found entail significant implications for managers in a wide base of industries adopting ISO 9001 philosophy, that can fashion their quality management systems and its principles to integrate expert systems in its process of customer satisfaction to improve the decisions making process and make a better use de resources.

It is also worth noting that, although the effectiveness of ISO 9001 has been widely mentioned in the literature as a significant parameter of quality management and company performance, there are no studies, to the best of the authors' knowledge, where the use of expert systems in the field of customers satisfaction is presented, it has allowed to improve the process of making decisions to increase the efficiency and effectiveness, since, until now, the studies have focused on analysing the different areas as Statistical process control (SPC), Quality Assurance, Inspection and Sapling, Control of production and Design of experiments.

Finally, this paper entails several contributions to the quality, firstly it analyses the process of customer satisfaction according ISO 9001 and secondly, it shows the steps for integration of expert system in process of customer satisfaction to help to the management of knowledge and help managers to make decision.

VIII. CONCLUSIONS

A system inspired by the need to improve and control important information for firms has been designed. It will promote a better satisfaction for customers according to norm ISO 9001:2015.

The system must accomplish the requirements derived from norm ISO 9001:2015, in paragraph "9.1.2. Customer satisfaction" a questionnaire to know about customer's satisfaction and needs is proposed.

For this objective, a questionnaire composed of 12 variables grouped in three parts has been designed: On one hand, those that allow the evaluation of products and services and; on the other hand, those that allow knowing the degree of information and communication that we offer and finally, a group that allows us to evaluate and validate the answer of customers.

Therefore, the system is focused in an optimization of resources and the automation of the process around customers' satisfaction by offering real information and, helping the decision makers to provide actions according to the obtained results.

To be able to apply this system to the customer's satisfaction, the analysis for extending it to the rest of the parts of the norm ISO 9001:2015 has been developed. Although it is not shown in this document, it allows opening important guidelines for research in this field, by implementing intelligent systems to analyse the results and making possible the decision making in the right way. As an example, aspects as the evaluation of providers, the verification of the state of the art of the products, etc. may be considered.

Then, and according to our results, the use and manage of this tool will reduce the response times in small and medium size companies where the system is implemented and will provide information for promoting quick managerial decision making, by considering the customers' opinions and being able to make corrections in a fast way to any unforeseen deviation.

The tool allows considering the satisfaction according to the norm ISO 9001:2015 and, what it is more important, it will serve us as a helping mechanism in the decision making process of the actions to consider from the obtained results in the answered questionnaires. This work opens up new research lines in this field, by contributing to the implementation of intelligent systems that are able to analyse the results and enables an easier decision making process. For instance, aspects such as the suppliers' evaluation, verification and acceptance of orders, etc. based on customer's opinions in real time are mentioned. Whenever firms use the system, problems can then be solved faster than earlier.

The present study suffers from some limitations. Although initially this tool has been optimally designed for use in small and medium-sized companies, it can be adopted by any organization independent of its size.

The influence of the Expert System and ISO 9001 on the company's performance has not been determined; it has only be focused on improving the customer satisfaction process, So, the above limitations suggest future research recommendations.

The future research studies can be based on analysis of factors that facilitate the adaptation of new tools based on artificial intelligence in the quality management system as this research proposes.

As well as analysing the relationship between the use of artificial intelligence in quality management systems in corporate performance, the use of technological adaptation indicators is needed. So, it is suggested that future studies incorporate such performance dimensions, on which the impact of ISO 9001 effectiveness can be determined.

The findings of this study present important practical implications, since there is an increasing trend for businesses all over the world to adopt standards of management practices, especially in small and medium-sized enterprises.

Our results have important managerial implications in line with their demands, since the description of Knowledge Management process within the customers' satisfaction context may help practitioners and managers interested in the implementation of expert systems in your quality processes in order to increase the possibilities of a successful adoption.

The authors further believe that by applying techniques and methodologies, such as those presented within this paper, it will permit to progress in this debate, hence, from a research implications perspective, this paper offers a broader understanding of customer satisfaction requirement according to ISO 9001 and of the phenomenon of knowledge extraction to turn it into rules, what it will facilitate continuous improvement in processes such as increases ISO 9001 effectiveness and as a consequence, tangible benefits will derive for a company.

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JOSE-AMELIO MEDINA-MERODIO graduated in marketing and market research from Rey Juan Carlos University. He received the degree in telecommunications engineering from the University of Alcalá and the Official master's degree in company management and the Ph.D. degree in administration and business management from Rey Juan Carlos University. He is currently an Associate Professor with the Computer Science Department, University of Alcalá. He acted as a Technical Management (Systems and Information Technology) Member with the Health Service of Castilla la Mancha, a Computer Technician with the ADAC Association, and the Head of quality, environment and computer services with Tecnivial SA Company.



CARMEN DE-PABLOS-HEREDERO is currently an Associate Professor (Accredited to full time Professor) of Business Organization, Rey Juan Carlos University, Spain. She is also the Head of the master's degree in Business Organization and the Logistic Processes Management SAP ERP. She has presented articles in international venues and published books and articles in impact indexed journals as *Agricultural Systems*, the *Journal of the Association for Information Science and Technology*, *Studies in Higher Education*, *Sustainability*, *Cities*, *Health Systems*, the *Journal of Work and Organizational Psychology*, *El Profesional de la Información*, the *Italian Journal of Animal Science*, the *International Journal of Environmental Research and Public Health*, *Transformations in Business & Economics*, the *Journal of Entrepreneurship & Management*, *Revista de Economía Mundial*, *Dyna*, *Interciencia*, the *Journal of Medical Economics*, REIS, and so on.



LOURDES JIMENEZ-RODRIGUEZ received the combined bachelor's degree and the master's degree in mathematical science from the Complutense University of Madrid, and the Ph.D. degree in computer science from the University of Alcalá. She has certified as a General Studies Professor through the University of Alcalá. She is currently a Professor with the Computer Science Department, University of Alcalá, in the field of information systems and languages an Professor/Advisor with the National University of Distance Education (UNED) in various levels of computer science and bachelor's degree level economics and business management and administration. She is also the Director of the master's in Management and Application of Knowledge of Self-Care in Nursing at the University of Alcalá, where she is also the Director of the Experto en Vacunación para Fomento del Autocuidado Comunitario (Expert in Vaccination for the Promotion of Community Self-Care) degree (three editions). She is a Principal Researcher on the Análisis y Mejora de la Efectividad Clínica de la Multiplataforma Web de Sistemas Expertos PbC2 (Plataforma Basada en el Conocimiento del Cuidado) [Analysis and Improvement of Clinical Effectiveness of the Multiplatform Web Sistemas Expertos PbC2 (platform based on care knowledge)] Project.



RAFAEL ROBINA-RAMIREZ received the Ph.D. degree in business and sociology, in 2002. He was an Assistant Professor with the University of Extremadura, Spain. He is currently teaching environmental ethics and management at the University of Extremadura. He is the author of several books and articles. He is also leading an Innovation Teaching Project at the Tourism Faculty in which he is involved in 35 academics from University. The projects main aim is to teach business ethic in a cross-sectional way, including empirical cases. He is researching about business and environmental ethics in its relation to teaching and learning methodologies.



LUIS FERNANDEZ-SANZ received the degree in computing from the Polytechnic University of Madrid (UPM), in 1989, and the Ph.D. degree in computing with a special award from the University of the Basque Country, in 1997. He is currently an Associate Professor with the Department of Computer Science, University of Alcalá (UAH). He has more than 20 years of research and teaching experience at the UPM, Universidad Europea de Madrid, and UAH, and a Main Researcher of more than 10 EU projects. He has also been engaged in the management of the main Spanish Computing Professionals Association (ATI) as the Vice President. He has held the position of vice president of the Council of European Professional Informatics Societies (CEPIS), from 2011 to 2013 and since 2016. His general research interests include software quality and engineering, accessibility, and ICT professionalism and education.



JOSE ANDRES-JIMENEZ received the degree in electronic engineering, in 2012, and the master's degree in advanced electronic systems and intelligent systems, in 2014. He is currently pursuing the Ph.D. degree in information and knowledge engineering focused in the application of the artificial intelligence in the development of standards for safety critical systems. After graduating from the Alcalá University in technical engineering in telecommunications, specializing in electronic systems, worked as a Computer Consultant for six years. He is also working at Indra as a Safety Manager from different projects and areas. He is a member of the Airworthiness Office, where he works as a Safety Compliance Verification Engineer (CVE). He has experience in the Safety Assessment of Critical Systems and in the Software Assurance in different applications and environments (Railway, Naval, Aerospace, Airborne, and Radar Systems). His research interests include safety and risk assessment and the transport sector. Other areas of interests are focused in artificial intelligence.

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