

Article

Digital Framework for Organizational Processes Improvement Using Quality 4.0 Concept, European Foundation for Quality Management (EFQM) and Key Performance Indicators (KPIs)

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Abstract

This paper's objective is to propose the Quality 4.0 App implementation framework and, based on it, the application software Quality 4.0 to improve and control the processes and facilitate the transition from a standard to a digital organization. Using quality management tools such as the Define, Measure, Analyze, Improve, Control (DMAIC) methodology, following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline, a study was conducted on three databases using the expression "smart organization" and 24 keywords were identified. The keywords, grouped in four categories—Industry 4.0, Sustainability, Digital transformation, and Employees—are assigned to the key performance indicators (KPIs) that require improvement. The association is made according to the eight Quality Principles stated by the Chartered Quality Institute (CQI). To observe the progress, the KPIs associated with processes receive scores using the European Foundation for Quality Management (EFQM) excellence framework. The resulting Quality 4.0 framework is developed using Microsoft Visio for the web (Microsoft Corporation, Redmond, WA, USA) and the Quality 4.0 App is developed using Google Appsheet for the web (Google LLC, Mountain View, CA, USA). This framework offers new perspectives for organizations ensuring process improvement through digital transformation to respond efficiently to the new challenges. It also contributes to academia by highlighting the necessity of rethinking traditional organizational processes to be human-centric, sustainable and efficient.

Keywords: quality management; DMAIC; smart organization; EFQM framework; radar chart; organizational processes; Quality 4.0 concept; Quality 4.0 principles; sustainability



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1. Introduction

Previous studies indicate that the role and function of quality management have evolved from the industrial sector, where its fulfillment and capacity to accomplish requirements were determined through inspection and control using statistical methods [1], and expanded its boundaries beyond the industrial sector to the services sector, such as in health [2,3], education [4], food industry [5] or government administration [6]. Other studies emphasize the new role of the quality management concept regarding Society 5.0 [7] and address the new role of focusing on social challenges to improve life quality and show how quality management can contribute to a human-centered development environment.

Consequently, the definition of quality has changed, evolving with the progress of society and technological changes, always feeling the need for an appropriate redefinition

of the term to be in direct relation with the times and requirements of the client. A quality management system provides a continuous framework for improvement, increases customers' and stakeholders' satisfaction, and provides confidence to the organization and its customers that it can deliver products that consistently meet requirements. Currently, we cannot talk about quality without thinking about business excellence. The classic concept of operational excellence has its origins in the 1970s, when J. Juran, as an expert, advised Japanese professionals about his methods [8]. Continuous business improvement using statistical methods and business excellence models such as the European Excellence Model EFQM [9] are a few of the classic methods and tools that organizations can use in their quest to be competitive in a global market. Organizations measure and compare their results to evaluate their degree of business excellence. Operational excellence and adoption of innovative technologies are essential elements that organizations focus on because they bring important benefits to all interested parties, from shareholders to customers, as well as indirectly to society. At the same time, their results must be in line with the 17 Sustainable Development Goals (SDGs promoted by the United Nations) [10] applied to all countries to reduce poverty, reduce inequalities, foster sustainable cities and communities, and implement climate action. This approach encourages organizations to analyze customer requirements, define the processes that contribute to achieving an acceptable product for the customer, and keep these processes under control.

As stated by Filos [11], an organization in the digital era will be structured on three interconnected dimensions: the first will be a virtual one, the second will focus on teamwork and the third will be the interconnection of knowledge. At the same time, it must be agile, permanently adapting to changes and quickly leveraging emerging opportunities. Industry 4.0 must be considered when discussing innovative technologies, the term being first used in 2011 [12], as well as the pillars that serve as its foundation: cloud computing, Big Data, the Internet of Things, cyber security, augmented reality, additive manufacturing and, implicitly, Quality 4.0.

However, the evolution of the last decade shows us the importance of using quality management techniques (Lean, Six Sigma, statistical process control (SPC), and Failure Mode and Defect Analyses (FMEA)) together with advanced digital technologies (artificial intelligence, big data analytics, cloud computing, and digital twins) as key factors to improve performance. Researchers and practitioners conclude that traditional methods become more powerful when supported by advanced digital transformation, providing for organizations benefits such as faster decision making, predictive quality management, real-time process monitoring, and transparent audits [13–15]. Consequently, developing a framework to support organizations in their transition to a modern organizational model has become a necessity. Such a framework should respond to changing customer requirements by combining traditional process analysis with innovative Industry 4.0 methods and technologies and continuous process improvement and monitoring.

The starting point consisted of observing the classic approach to quality and also the new one and thus bringing technological progress to the forefront and using both opportunities where applicable for organizations to adopt the smart transformation as highlighted in Table 1.

The recent studies developed by Salimbeni et al. [16], Xu et al. [17], and Kallmuenzer et al. [18] reveal that large and medium-sized organizations are more prepared to deal with changes than small organizations which are less nimble to change for reasons such as availability of resources (especially appropriate technologies), workforce, organizational culture dealing with potential risks and possible changes. Therefore, there is a call for a different approach that addresses the latter segment of the market that uses the above key factors together.

Table 1. Prospects for the new notion of quality approach.

Criterion	Traditional Quality Management	Quality 4.0
Focus	Manual process control	Integration of digital technologies for continuous monitoring and optimization
The role of man	Manual monitoring, periodic inspection	Close collaboration and interaction between humans and technology
Main Tools	Charts, checklists, traditional audits	Sensors IoT, AI, Machine Learning, Cloud Computing, Blockchain, Digital Twins, Robotic Process Automation (RPA), Cybersecurity Technologies, Augmented Reality (AR) and others.
Nature of the processes	Predominantly human-dependent manuals and instructions	Automated, continuous, predictive and proactive

The initial stage for the research begins with the following statement:

Standard organization that applies classic quality improvement methods and implements the latest technologies targeting new research and discoveries in the industry, all within a sustainable framework, becomes a smart organization.

In our attempt to demonstrate the above statement, the following questions were identified:

- What are the attributes and keywords that characterize smart organizations?
- What criteria, methods or tools could an organization use to identify that its services and products correspond to the current state and requirements of customers?
- What modern methods can be emphasized so that a traditional organization can transform into an organization in accordance with the new requirements of the market and customers, highlighting the barriers that stand in the way of change and the strategy necessary for digital transformation?

2. Materials and Methods

2.1. Research Methodology—Define, Measure, Analyze, Improve, Control (DMAIC)

Existing research explores quality management, supply chain resilience, and Industry 4.0 readiness for digital transformation [19]. There are also studies that examine how lean and agile strategies mitigate organizational risks and strengthen supply chains in manufacturing [20]. In contrast, the research literature suggests advanced methods, such as the integration of machine learning with Six Sigma, to improve production and the detection of defects [21]. A significant focus is placed on Small and Medium Enterprises (SMEs), evaluating their capabilities to adopt disruptive technologies and bibliometric analysis, structural equation modeling, and case studies are used to provide a comprehensive view of modern industrial trends [22]. Investigations that focus on key readiness indicators help companies to reflect on their starting point before implementation [23], but newer studies introduce Industry 5.0 concepts to include human-centricity, sustainability, and resilience as core dimensions of maturity [24].

To conclude with, within comparative analysis between papers related to industrial engineering and quality management, it can be observed that some general aspects are driving the present industry: while the authors share a common interest in digital transformation, they emphasize that achieving operational excellence requires a strategic balance between technological innovation, organizational culture and classical methods [25].

In the light of the present conducted research several critical barriers were identified in adopting digital strategies that prevent organizations realizing their objectives: orga-

nizational silos and poor coordination, inadequate information transfer between supply chain participants and fragmented internal processes (that create bottlenecks that hinder the transparency required for digital integration), financial and resource constraints, and knowledge and competency gaps [26].

To answer the above questions and demonstrate the statement, a study that applied the Define, Measure, Analyze, Improve, Control (DMAIC) methodology was developed and, after its completion, conclusions were drawn and organization improved the processes. Firstly, identification of a model for the digital transformation of a small organization was considered, similar to the study of Tranfield et al. [27], and a meta-analysis of the literature was performed [28], the keywords obtained being presented in Supplementary Materials, Tables S1–S5. Based on the related keywords that define the smart organization obtained, a digital framework to transform the organization was elaborated and the digital app for monitoring, control and improvement was created.

2.1.1. Define Phase

The research was carried out according to Page et al. [29] as in Figure 1 and the expression “smart organization” was used to identify the relevant articles for the study. This was the Define Phase, and the keywords relevant for a smart organization were collected. The obtained result centralizes the new attributes characteristics of smart organizations. This section also synthesizes results identified in articles from three databases: Springer Nature, Taylor and Francis and Elsevier over an interval of approximately eight years from 2016–2024, which includes the year 2020, dominated by the COVID pandemic (which accelerated the pace of digitalization). It used the search engine existing on the page of each source above, and the search technique used the below filters:

- Relevant period analyzed 2016–2024;
- Expression used: “smart organization”;
- Mainly, using the site’s filtering, only articles in English were searched, excluding conference abstracts, conferences, editorials and article reviews, books;
- Sciences researched: Engineering, Business, Management and Accounting, Computer Science, Engineering, Economics and Finance, Environmental Sciences, Materials Science, and Business Strategy and Environment;
- Centralization of the results obtained.

In this phase a rigorous selection was made of the results obtained for each database individually, eliminating duplicates, as well as any works that did not respect the format proposed at the beginning; then, the key terms (keywords) were extracted from the final articles obtained from each database, articles without keywords were eliminated, errors and fonts were corrected, and the text was processed, for example, the abbreviations IoT and COVID-19 being assimilated with the whole words, e.g., Internet of Things and Coronavirus, to avoid double counting, and inconsistencies were eliminated. The keywords were grouped by the number of their appearance (occurrences) for each database and the keywords with more occurrences were kept and, if possible, eliminated if they had only one occurrence.

Findings from the study were classified under the “smart organization” expression and included the 24 attributes (remaining keywords) listed and grouped below:

- User experience, Digital Divide, Augmented Reality, Supply Chain Management, and Global Digitalization;
- Digital Twin, Digital, Sensors, and Cybersecurity;
- Climate Change, Circular Economy, Energy Storage System, and Carbon Footprint;
- Self-Assessment, Cloud Computing, Deep Learning, Blockchain, Internet of Things, Machine Learning, and Business Model;

- Education, Capability Development, Human-Centered Computing, and Resilience.

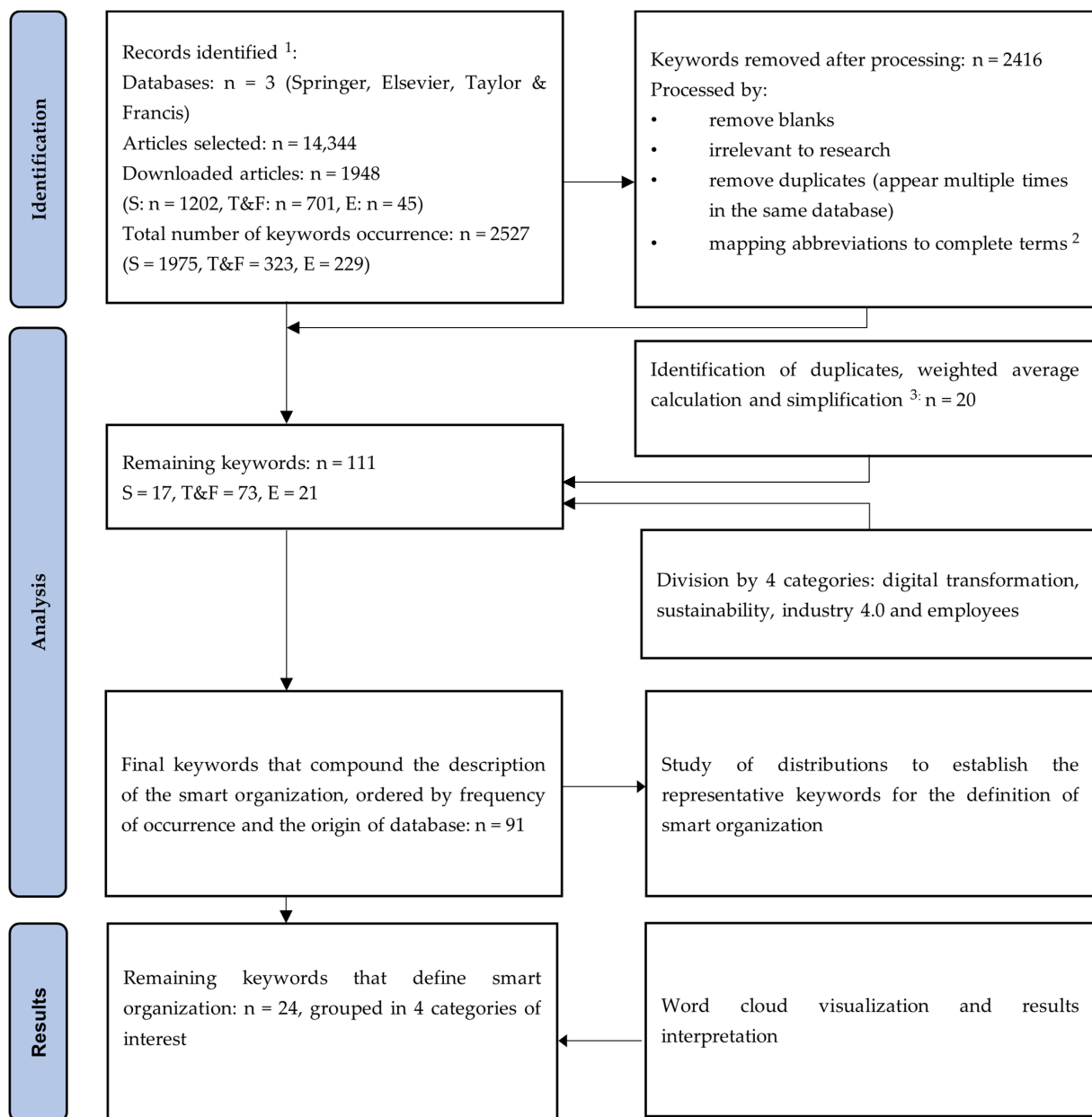


Figure 1. Identification of keywords that define smart organization. Legend: S—Springer, T&F—Taylor & Francis, E—Elsevier. ¹ Articles from the three databases, in English, excluding conference abstracts, editorials and article reviews, books. ² Abbreviated terms have been assimilated within the same database (e.g., IOT = Internet of things). ³ Simplified words (only one record remained) where they appeared in two or all three databases; the number of occurrences in each database was retained and was made a weighted average of the number of occurrences in all three databases together.

The keywords were grouped according to their affinity towards the four categories of interest: Industry 4.0, Digital transformation, Sustainability, Employees as in Table 2.

Industry 4.0 focuses on the application of advanced digital technologies to create smart manufacturing and industrial processes.

Digital transformation is wide and strategy-driven.

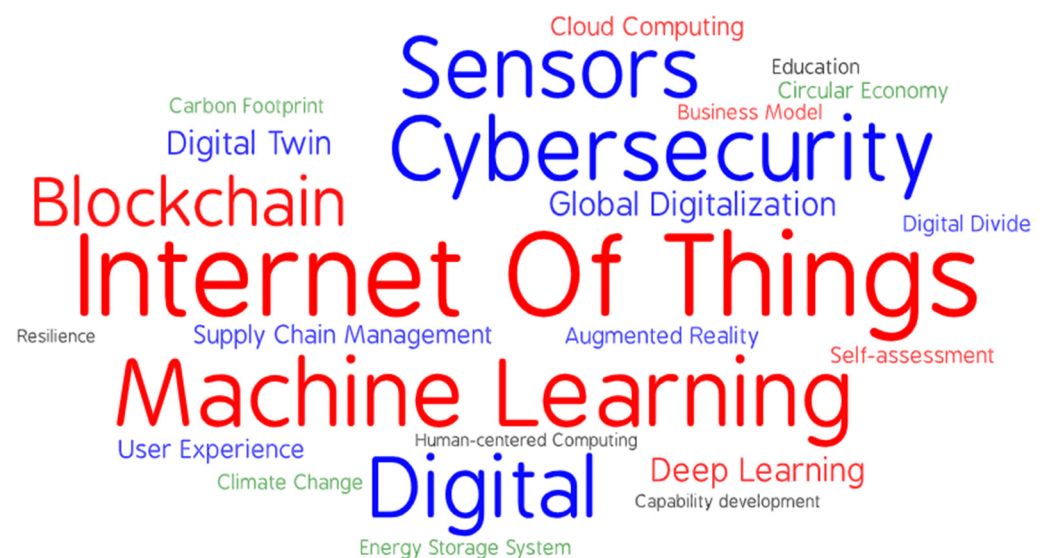
Sustainability balances economic, environmental, and social needs for long-term value creation.

Table 2. Listed keywords that define the smart organization by categories.

Category	Keyword	Average Occurrences Values
Industry 4.0	Internet of things	32
Industry 4.0	Machine learning	32
Digital transformation	Cybersecurity	28
Digital transformation	Digital	26
Digital transformation	Sensors	26
Industry 4.0	Blockchain	26
Digital transformation	Global digitalization	14
Digital transformation	Digital twin	14
Industry 4.0	Deep learning	14
Digital transformation	Supply chain management	13
Digital transformation	User experience	11
Industry 4.0	Cloud Computing	11
Digital transformation	Augmented reality	10
Digital transformation	Digital divide	8
Sustainability	Circular economy	8
Industry 4.0	Self-assessment	8
Sustainability	Climate change	5
Industry 4.0	Business model	4
Sustainability	Carbon footprint	3
Sustainability	Energy storage system	3
Employees	Education	3
Employees	Resilience	2
Employees	Human-centered computing	2
Employees	Capability development	2

Employees drive innovation, adaptation, and organizational development.

A visual representation of the centralized terms in the form of a word cloud that defines the smart organization was obtained in Figure 2. The frequency of the terms that characterize the new type of organization, as well as the share of their use in analyzed articles are closely related to the newly emerged technologies. It can be observed that there are terms that have a higher degree of use compared to others, this indicating greater relevance when talking about smart organizations.

**Figure 2.** Word cloud visualization (the four categories are represented by colors: Employees—Black, Industry 4.0—Red, Sustainability—Green, and Digital transformation—Blue).

The terms obtained were grouped into categories and each category color distinguished for clarity. These were considered when developing the application and used as key improvement factors.

2.1.2. Measure Phase

European Excellence Model (EFQM) used by thousands of organizations around the world, according to their report, is a valuable tool for self-assessment of an organization, providing directions for achieving organizational excellence and improvement. The main characteristics of the EFQM framework are the three evaluation directions (Direction, Execution and Results), the seven criteria and sub-criteria and, finally, the radar evaluation. The EFQM model is in line with the evolution of the industry and the market, therefore, is constantly changing. The organizations that aim for excellence need to be evaluated in accordance with the model and receive scores that certify their recognition and evolution. The indicative guidelines criteria they should accomplish and the points they should achieve are centralized in Table 3.

Table 3. Evaluation criteria and sub-criteria according to the EFQM 2020 model.

Eval.	Criteria						
Direction 200p	Criterion 1. Purpose, vision, strategy						
	1.1 Purpose and vision 20%	1.2 Stakeholders need 20%		1.3 Ecosystem, capabilities, challenges 20%	1.4 Developing a strategy 20%	1.5 Performance management system 20%	
	Criterion 2. Organizational culture and leadership						
	2.1 Culture and values 25%	2.2 Conditions for change to occur 25%			2.3 Creativity and innovation 25%	2.4 Vision, purpose, and strategy 25%	
Execution 400p	Criterion 3. Stakeholder engagement						
	3.1 Customers: a lasting relationship 20%	3.2 Staff: develop and retain 20%		3.3 Business parties: support and security 20%	3.4 Organization: well-being and prosperity 20%	3.5 Partners and suppliers: sustainable value 20%	
	Criterion 4. Sustainable value creation						
	4.1 Designing value 50%	4.2 Communicate and sell value 50%			4.3 Deliver value 50%	4.4 Experience as a whole 50%	
	Criterion 5. Tracking performance and change						
Results 400p	5.1 Performance and risk targets 20%	5.2 Organization for the future 20%		5.3 Drive innovation 20%	5.4 Information, data and knowledge 20%	5.5 Manage resources 20%	
	Criterion 6. Stakeholders' perception						
	6.1 Customer perception 20%	6.2 People's perception 20%		6.3 Perception of business 20%	6.4 Society's perception 20%	6.5 Partners and suppliers 20%	
	Criterion 7. Operational and strategic performance						
	7.1 Purposes and sustainable value 25%	7.2 Financial performance 25%	7.3 Stakeholder 10%	7.4 Strategic objectives 10%	7.5 Performance management 10%	7.6 Driving transformation 10%	7.7 Predictive measures 10%

To achieve our objective of designing and implementing a framework to improve organizational processes through digitalization, we assigned each sub-criterion of the EFQM framework a score in accordance with the relevance allocated by the organization and stakeholders' expectations between 10% and 50%.

In the following step, we used the data from the measured processes of the studied organization and percentages were transformed into points. In our case there were nine processes: management analysis k_{ob} , human resources k_{as} , design and development k_L , sales $k_{delivery}$, marketing k_{vm} , service k_{serv} , purchasing k_A , customer satisfaction k_{CMT} , and non-compliance prevention k_{nlunar} . Each one of them needs to be improved to reach for the maximum number of points allocated, which represents 100% fulfillment.

Management analysis k_{ob} , human resources k_{as} and design and development k_L are included in the Direction category, and they count together 200 points in the EFQM framework, the first having 100 points and the next each 50 points. These maxim points correspond to 100% fulfillment of the target performance, which means they have to reach, respectively, values of 4, 4 and 0.1 as being the maxim value when process fulfilment is reached. These last values were calculated mainly as a report between result obtained and target result.

Sales $k_{delivery}$, marketing k_{vm} , service k_{serv} , and purchasing k_A are included in the Execution category, and they count together 400 points in the EFQM framework, each having 100 points. These maxim points correspond to 100% fulfillment of the target performance, which means they have to reach, respectively, values of 12, 0.5, 0.5 and 0.1 as being the maxim value calculated when process fulfilment is reached. These last values were calculated mainly as a report between result obtained and target result when processes were measured.

Customer satisfaction k_{CMT} and non-compliance prevention k_{nlunar} are included in the Results category, and they count together 400 points in the EFQM framework, each having 200 points. These maxim points correspond to 100% fulfillment of the target performance, which means they have to reach, respectively, values of 0.2 and 0.1 as being the maxim value calculated when process fulfilment is reached. These last values were calculated mainly as a report between result obtained and target result when processes were measured.

The boundaries of the process's indicators and their main target value indicators have been obtained in Table 4. After that, improvement actions, which use the tools specific to Industry 4.0 and at the same time aim for excellence, in line with the EFQM framework, were proposed. Implementation of the measures improved the organization's processes and led to increased customer satisfaction, improved quality and enhanced organizational performance.

The steps to measure processes were as follows:

- Each process was measured before improvement;
- Depending on the organization's requirements, corresponding score was assigned;
- The percentage difference required to reach the target % was calculated with Formula (1);
- A radar graph is drawn up with the two measurements (target value and after improvement value) that offered a holistic assessment of the organization at any time.

$$ABS \text{ (Target value} - \text{Value after improvement)} / \text{Improvement value} \times 100 \quad (1)$$

It is observed that there are different trend lines for processes to reach for their target: ascending or descending; for some, performance means to obtain increased values and, for others, to reach the target means to decrease. Therefore, the score required to reach the target was calculated as a module, an absolute value of the difference between the target and the actual state. After that, the percentage to target % was calculated, as a

division of score to reach the target values and value after improvement and multiplied by 100, being necessary to calculate a percentage. In the next step we could calculate points needed to reach target, calculated as a division of percentage to reach the target and target points multiplied by 100 for all the values. In the end, points achieved were calculated as a difference between target points and points needed to reach the target. In this phase the radar graph can be obtained to observe the company's evolution.

Table 4. EFQM framework and process evaluation for changing into a smart organization.

EFQM	Process	Measure			Target Points P	Score to Reach the Target	Percentage to Target %	Points Needed	Points Achieved
		Initial	After Improve	Target/Trend					
Direction	Management analysis k_{ob}	3.6	3.6	4 ↑	100	0.4	11	11	89
	Human Resources k_{as}	3.86	3.86	4 ↑	50	0.14	4	7	43
	Design and development k_L	0.2	0.18	0.1 ↓	50	0.08	44	22	28
Execution	Sales $k_{delivery}$	14	12.5	12 ↓	100	0.5	4	4	96
	Marketing k_{vm}	0.47	0.47	0.5 ↑	100	0.03	6	6	94
	Service k_{serv}	0.9	0.6	0.5 ↓	100	0.1	17	17	83
	Purchasing k_A	0.3	0.2	0.1 ↓	100	0.1	50	50	50
Results	Customer satisfaction k_{CMT}	0.28	0.28	0.2 ↓	200	0.08	29	57	143
	Non-compliance k_{nlunar}	0.17	0.15	0.1 ↓	200	0.05	33	67	133

↑ upward trend (improvement means higher value). ↓ downward trend (improvement means lower value).

2.1.3. Analyze Phase

In this phase, the values obtained from the previous phase were used as examples to illustrate the changes of the implemented measures within the organization and the radar chart was obtained as in Figure 3 to compare results with the target values. This was used to observe the changes and to develop the framework for digital transition of the organization.

The data obtained indicated that the organization has achieved the improvement of the initial results but, to achieve excellence, continuous improvement was needed, so the organization needs to implement measures such as a digital application that provided an overview and support for monitoring, improvement, evaluation and communication between employees and management. The Quality 4.0 app UI was created in Miro (Miro, Amsterdam, Netherlands; web application, accessed 10 October 2023), developed in Appsheet (Google LLC, Mountain View, CA, USA; web application, accessed July 1, 2025) and ran on phone, laptop and desktop in AppSheet v17.5 (Google LLC, Mountain View, CA, USA).

Contains elements related to:

- Evolution of processes;
- The degree of achievement of objectives;
- Data related to the organization's carbon footprint from the sustainable point of view;
- Notifications regarding the achievement of objectives;
- Documentation related to processes that are permanently improved.

The advantages offered by the EFQM model were used and the measurements of the processes were evaluated using performance indicators. This information is kept in Google Sheets (Google LLC, Mountain View, CA, USA; web application, accessed 1 July 2025) in cloud and is retrieved and updated permanently through the application. Where data is

not available, the measurements being carried out at different intervals, the initial value is used to have a picture of the organization.

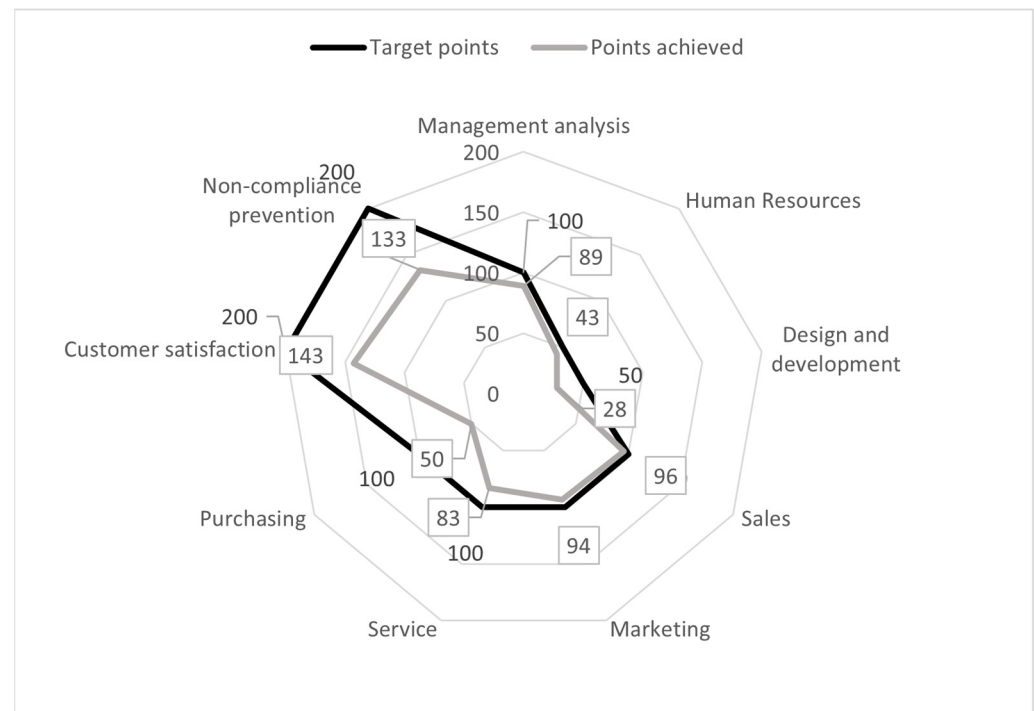


Figure 3. Analysis of indicators measured after improvement based on EFQM criteria: points achieved and target points.

2.1.4. Improvement Phase

In our goal to transform an organization, it was considered that the process's improvement indicators must align to the new eight quality principles identified by CQI in collaboration with Leeds University and Oakland Institute for Business Research and Education [30], respectively:

- Principle 1: Collaboration to achieve added value (customers are constantly redefining their values and how they want to consume it, making digital servitization an important driver of value co-creation);
- Principle 2: Cybernetics (Vertical and Horizontal Systems Integration of digital technologies improve supply chain management by using data and connected systems to optimize operations);
- Principle 3: Transparency, collaboration in complete safety (value chains become smarter, connected and work together while customers are sharing their data, so organizations need to work together, be transparent, and manage risks to succeed in the connected environment);
- Principle 4: Cyber-physical systems (people and technology interact as technology advances, so the relationship between them continues to change, while some tasks become automated, it also creates opportunities for newer activities for people);
- Principle 5: Mutual trust (responsible use of data and trust in digital technologies that can help organizations work securely and efficiently to prevent fraud, handle risks and operate effectively);
- Principle 6: Adaptive and continuous learning (organizations use data to adapt quickly, to innovate, and to create greater value for their customers and also to predict or change customer needs);

- Principle 7: The value of data (data becomes a strategic asset and to improve quality and make informed decisions; quality professionals need skills in managing, organizing, processing, and analyzing data, ensuring its reliability and security in the business context);
- Principle 8: Technology and human intelligence combined (advanced technologies, such as machine learning or artificial intelligence enhance human capabilities while working together; therefore, their collaboration supports better decision making, continuous learning and faster responses for optimization of quality processes).

Tools from applications used in industry and also innovative technologies in relation to the new principles above and together with the results obtained from the study regarding the technologies that define smart organizations above were considered as instruments to improve standard organization. We choose predefined elements, which the organization intends to implement, thus bringing elements that ensure the implementation of new technologies but also added value to customers. Consequently, the transformation of the organization into a digital organization was achieved, in accordance with customer requirements.

In the backend, the Quality 4.0 application will contain the association of the unfulfilled Kpi indicators with the corresponding attributes of the eight Principles of Quality 4.0, through cloud keywords, defining the necessary measures for improvement.

The list of specific tools related to the new principles can be permanently enriched according to the specifics of the activity as well as in direct connection with the associated principles. For example, Principle 4 Cyber-Physical Systems (interaction between humans and technology) was associated with the following tools: task automation, machine learning, and virtual twin, as potential applications that would improve the organization's processes. The tools to identify how to transform a standard organization into a smart organization are centralized in Table 5.

Table 5. The attributes of the CQI principles.

P1 Added Value	P2 Vertical and Horizontal Integration	P3 Transparency and Collaboration	P4 People Technology Interaction	P5 Responsible Use of Data	P6 Adaptive and Continuous Learning	P7 Data Value	P8 Technology and Intelligence Combined
form	vertical and	cyber	automated	large volume	data recording	QR codes	cloud
calendar	horizontal recordings	security	workloads	of data			technology
	two-way data	security	machine	smart assistant	data	blockchain	biometric
responsibilities	collection	protocols	learning	conversation	predictability		authentication
	system logs	authentication	digital twin	robot	digital commu- nication	Add	Add
Add	date register	Add	Add	Add	Add		
	record history						
	email archives						
	Add						

Subsequently, these were implemented within a Quality 4.0 application, developed to track how the organization evolves but also for an efficient implementation of the proposed improvement measures.

The development of the application was based on the method of the authors for transforming a standard organization into a smart organization, as well as the EU Directive related to sustainability and climate change and greenhouse gas emission [31]. These regulations aim for climate neutrality by 2050; therefore, the development of the app required the sustainability criteria for organizations. The application monitored the organization's carbon footprint at a given time and also could monitor to what extent the organization has achieved its environmental goals.

Tools such as the organization's processes, measuring them with the help of Kpi indicators, and the EFQM framework, which aims for excellence as a benchmark for process improvement, were used. The Kpi indicators were assigned points and the percentage needed to achieve the preset objectives was determined. Within the application, for the selected processes that need improvement, Table 6 resulted. Thus, the connection was made between achievement degree of the pursued objectives and the proposed target using the EFQM model and the new objectives related to Quality 4.0 and Industry 4.0.

Table 6. Correspondence between the EFQM model, the Kpi tracked for improvement and the new CQI principles within the Quality 4.0 application.

EFQM Criterion	Process	KPIs	CQI Principle	Measure	Control	Responsible
Direction	Management analysis	k_{ob} (degree of objective's fulfilment)	Principle 1	app development	Semester	QMS Resp.
	Human Resources	k_{as} (satisfaction of employment)	Principle 4	automation software for repetitive tasks	Annual	Head of Production Resp. HR Resp.
	Design and development	k_L (inventory)	Principle 1 Principle 7	identifying parts on manufacturing flow based on QR codes	Monthly	Head of Production Resp
Execution	Sales	$k_{delivery}$ (average time to make a piece of equipment)	Principle 2 Principle 6	supplier's needs analysis with a rapid learning system; transparency related to customer	Monthly	QMS Resp. Sales Resp.
	Marketing	k_{vm} (number of visitors)	Principle 1 Principle 2	program to measure the site's pulse	Quarterly	Marketing Resp.
	Service	k_{serv} (customer's satisfaction)	Principle 1	using a form to assess the client's equipment	Monthly	Service Resp.
	Purchasing	k_A (non-conformities in purchasing process)	Principle 3	evaluation report of the suppliers; requirements' complaint score	Monthly	Purchasing Resp.
	Customer satisfaction	k_{CMT} (average cost of production/product)	Principle 8	products with parts in the cloud; solution for optimal prices and delivery times	Quarterly	QMS Resp.
Results	Non-compliance prevention	k_{nlunar} (reducing the number of non-conformities of the delivered products)	Principle 1	cloud solution per product for easy tracking of of the working instructions	Monthly	Head of Production

This way resulted in the transformation of the standard organization into a digital organization. Where data is not available, measurements being taken at different intervals, initial values were used to have a picture of the organization at that time.

Following the implementation of these recommendations and considering the eight principles of the new Quality 4.0 theory, according to the Chartered Quality Institute, a simple implementation framework was developed, namely a methodology that supports small and medium-sized organizations in the transition process towards a digital model. This allows for efficient monitoring of processes and, at the same time, increased organizational performance. Based on the connection between input and output data processes, the Quality 4.0 app was developed. After the user signs in, based on predefined credentials (user and password), the front-end of the app contains user interface elements: KPIs, processes,

improvement actions and alerts. Each of the previous interface elements is connected to data collected in processes monitored by the organization as in Figure 4.

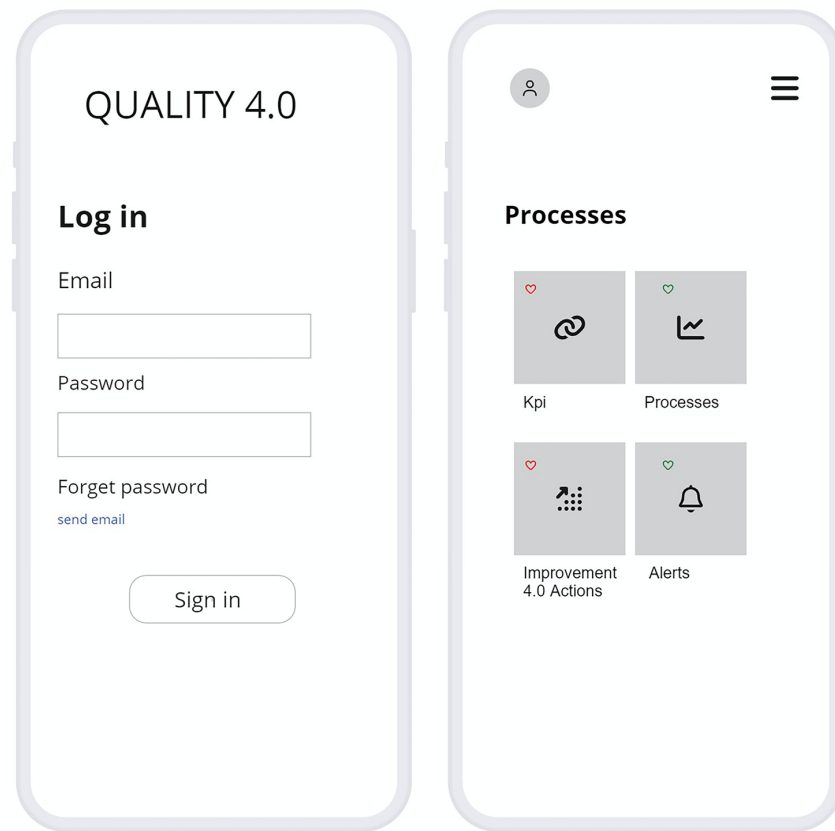


Figure 4. User interface connection and elements.

2.1.5. Control Phase

Improvement of the organization's results was observed, and the Quality 4.0 App was subsequently implemented and tested. After one month of implementation, greater transparency was obtained in terms of knowledge and evolution of the organization as well as the results of the implementation of the improvement measures. Visualization of the implemented measures is at hand and could be monitored for better and rapid decisions. The methodology of transforming a traditional organization into a smart organization can be applied by using the application software dedicated to small and medium-sized organizations in the private sector that have a quality management system implemented or in the process of being implemented, called Quality 4.0. The application aims to optimize processes, identify risks and opportunities, as well as continuously improve organizational activities. The Quality 4.0 app is supposed to maximize and increase awareness among employees about the significant role they have in performing daily tasks. In the control phase, directly involved personnel could appreciate the efficiency of the implemented measures. In Figure 5a it can be observed that the evolution of the key performance indicators is satisfactory and offers information about the processes: four of them being on an ascending trend, market as very good and five of them being on target. In Figure 5b certain aspects related to sustainability are highlighted, respectively, the organization carbon footprint measured in kgCO_{2e} over the last 4 years (depending on the available data at the evaluation moment).

The development of the application contains data collected from the previous studies conducted. Classical methods such as SIPOC, Pareto analyses, 5WHY method, FMEA

analyses, RADAR Graph, ISO 9000 standards [32], EFQM framework, and GHG Guide were used for the analysis and improvement of the processes followed by their innovation using new methods and techniques, and the transfer to a modern organization was achieved efficiently and within a reasonable time. The organization direction could be observed easily as in Figure 5.

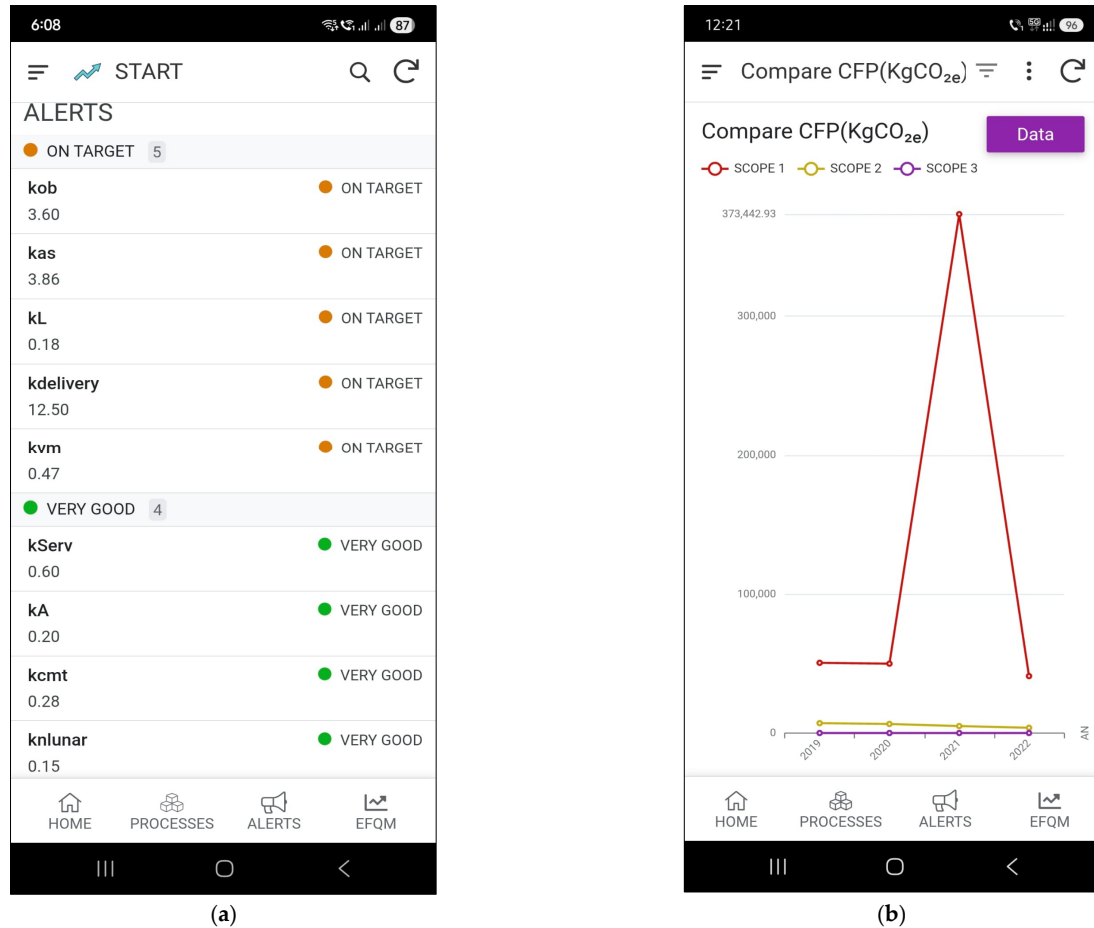


Figure 5. Smartphone visualization of Quality 4.0 App indicating organization direction and changes. (a) Alerts section contains the main info regarding the organization direction together with key performance indicators evolution trend; (b) EFQM section offers statistics regarding organizational carbon footprint over a certain period.

In the backend, the Kpi values related to processes that did not reach target or are not yet evaluated are analyzed and necessary points to reach the target are calculated according to the EFQM framework and actions for improvement are allocated. They are divided by EFQM criteria as in Figure 6.

Together they sum up 1000 up points. Each process is analyzed using the data collected and the score achieved is identified. If the target is not reached, then alerts are generated and actions for improvement must be chosen from the new technologies as in Figure 7.

Each process is measured and controlled as in Figure 8. Data from each process is compared with target.

In the front end results a graph representing the value points reached and, based on it, decisions regarding necessary action that must be applied are chosen from the proposed measure from the Industry 4.0 and the new technologies. These are represented as in Figure 9a (graphical representation of results) and Figure 9b (implementation of the improving measures).

Using the EFQM concept and its main criteria the organization was assessed and the measures for improvement are selected using Quality 4.0 App functionalities. These measures are at hand and could be selected from the list suggestions following the new principles of quality suggested by CQI in their study.

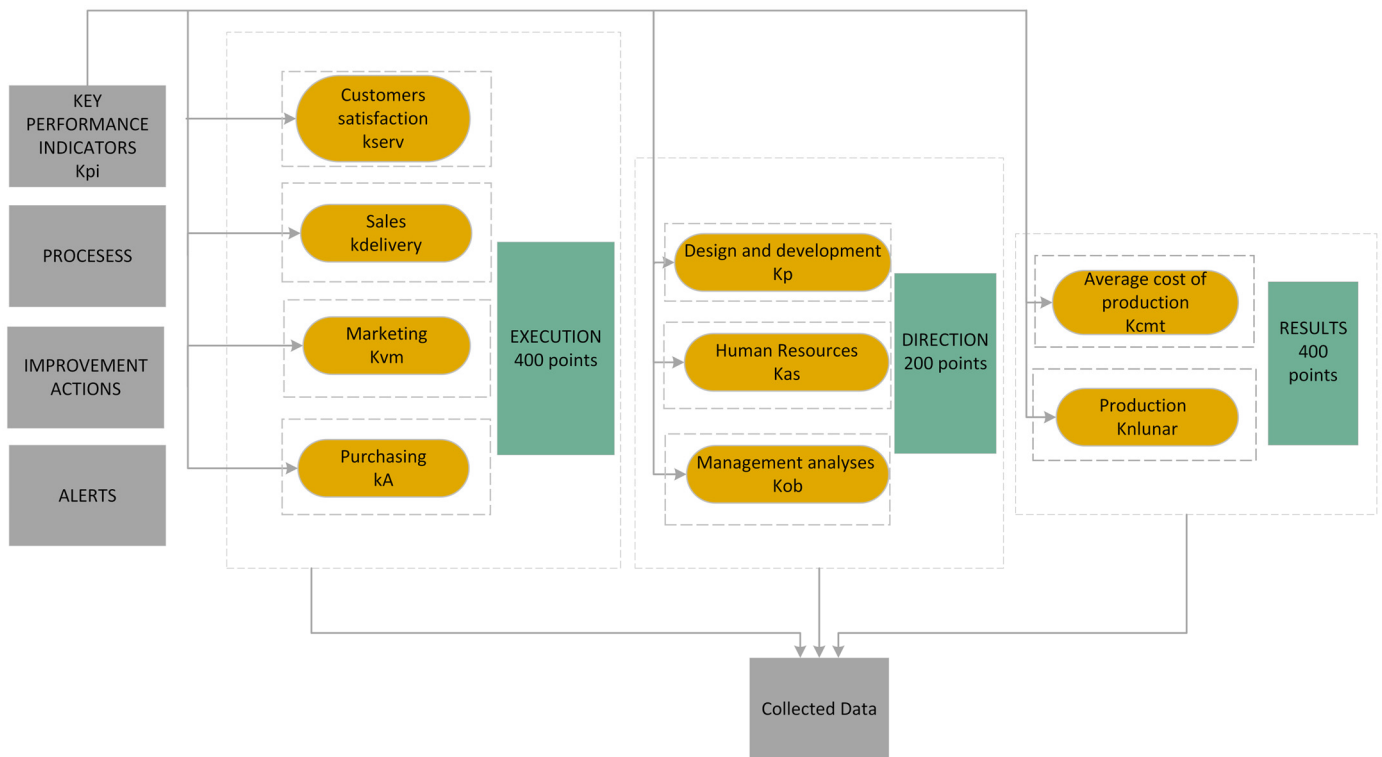


Figure 6. Points allocation for Kpi.

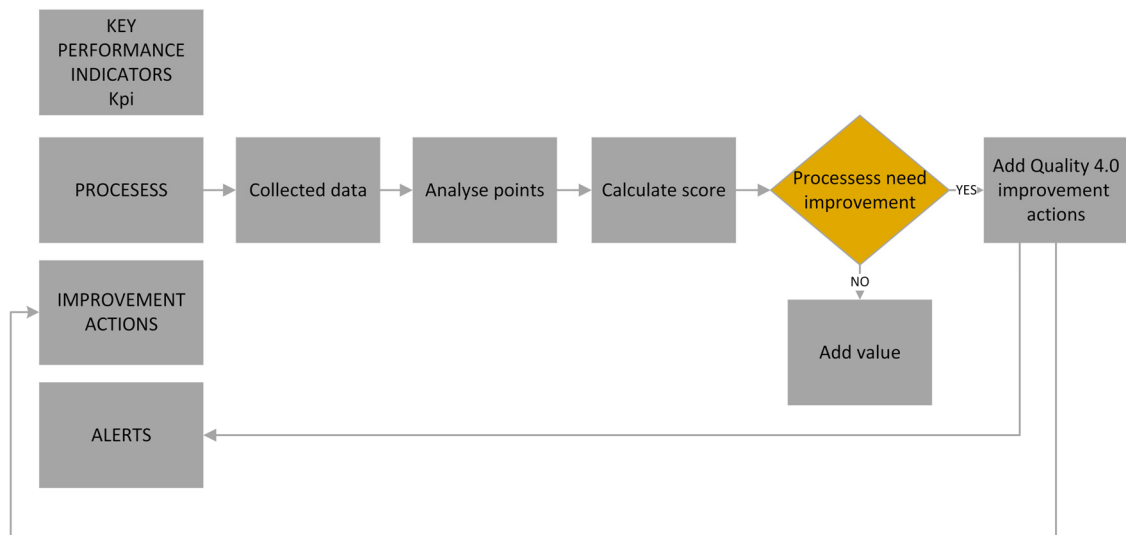


Figure 7. Generated alerts and actions for improvement.

Even if the target is reached the personnel could propose measures for added value to increase the organization's customers' satisfaction and wellbeing.

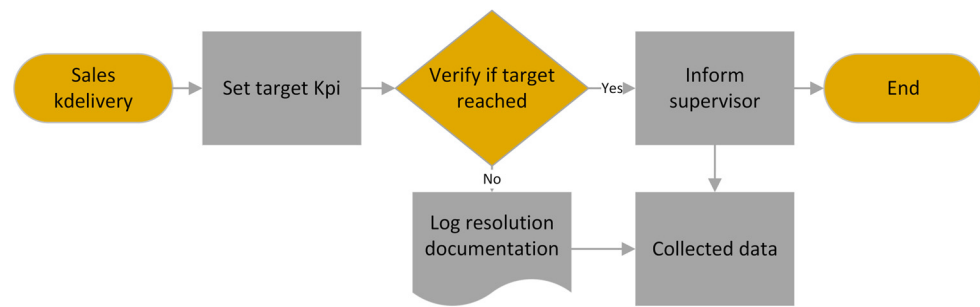


Figure 8. Process control action.

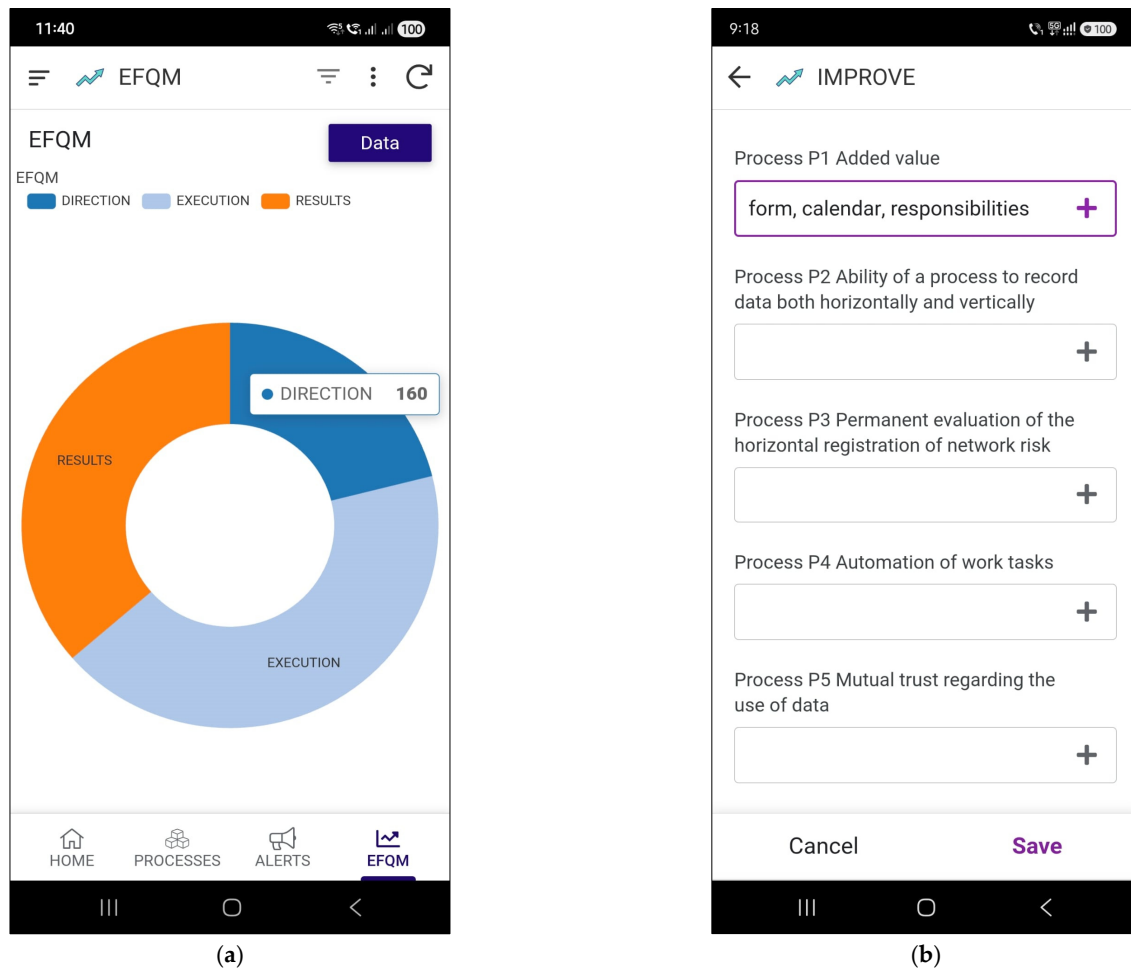


Figure 9. Smartphone capture of Quality 4.0 App indicating control of EFQM points achieved and action improvements assignment. (a) Points achieved in relation to EFQM framework and organization target; (b) measures for improvement proposed.

3. Results

To reach our objective, the transition from a standard to a digital was obtained by integrating classical quality concepts: DMAIC methodology, EFQM criteria, and KPI indicators with the concept of Industry 4.0 and the keywords associated. The relationship between them is illustrated in Figure 10.

Another benefit obtained was simplifying the processes' revisions, ensuring easy access to documents, as well as ease of creation, storage and use of documentation. In addition, the app offers functionalities as automatic notifications, reducing time spent on administrative activities and supporting process improvement. Other advantages obtained

were diminished costs associated with quality, increased accessibility through mobile devices and PCs, increased staff involvement, reduced costs compared to existing solutions on the market and increased productivity. At the same time, organizations that use this method will benefit from an easier analysis of compliance with the criteria of excellence.

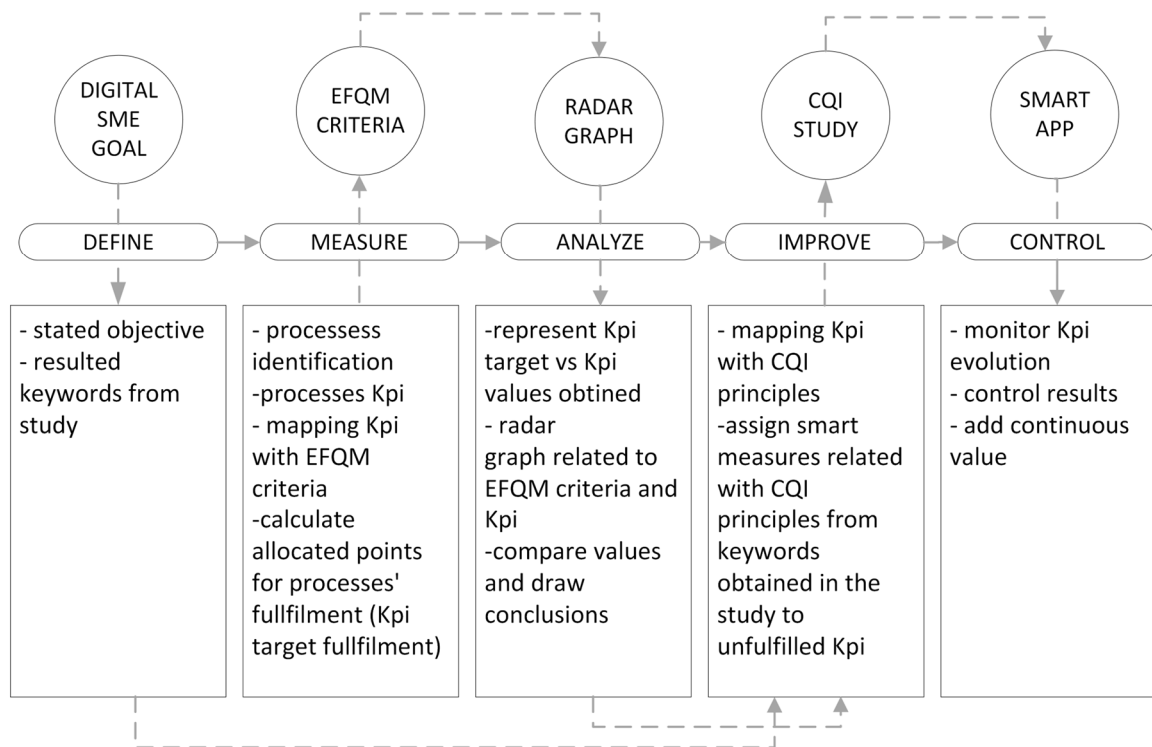


Figure 10. Classic quality concepts integration in transition to a smart organization.

The Quality 4.0 application is hosted in Google Cloud (Google LLC, Mountain View, CA, USA). It can be installed on the mobile phone, but it is also accessible from the browser. It is accessed by authorized personnel in an organization who can make appropriate decisions. Within the organization, it can be accessed at any time by all staff, on a limited rights basis, to observe the status of the organization at a given time for informational purposes. Read and writing permissions are set for each user, so all the staff have access to the app for viewing, but only delegated staff have access to both changes and read.

The application contains data on:

- Boundary set of the processes and their main measurement indicators;
- Collection of data related to indicators;
- Scores assigned to processes based on importance;
- Target values for indicators;
- Proposals for improvement measures following those set out in the previous chapters;
- Measurements, scores and values obtained after the application of improvement measures.

Smart organizations create the right conditions to stimulate innovation, which in turn creates profitability by increasing efficiency and gaining competitive advantage; reinvesting profits also improves smart capabilities and innovation.

4. Discussion

Sustainability is the sum of economic, environmental, and social dimensions that places people and their well-being at the forefront while adhering to careful management of resources and analyzing the impact of the results of activities on society. Organizations

are expected to consider together the interests of their stakeholders, employees, customers, suppliers, local communities, and next generations, being also responsible for minimizing pollution, reducing greenhouse gas emissions and using resources efficiently. So, including these three dimensions into processes, organizations generate value and innovation, while protecting the environment and social welfare being sustainable.

Therefore, organizations need a change, and transformation must start from the way processes are conducted, improving the quality of the results obtained. To identify the extent to which the organization's services and products correspond to the current state and requirements, it is necessary to analyze the processes whether they achieve the expected results and their pre-established objectives or need improvement.

Industry 4.0, which brings benefits, cannot exist without innovation and performance cannot exist without quality. For this purpose, the concept of improving and transforming an organization from a standard organization into a smart organization was proposed as in Figure 11.

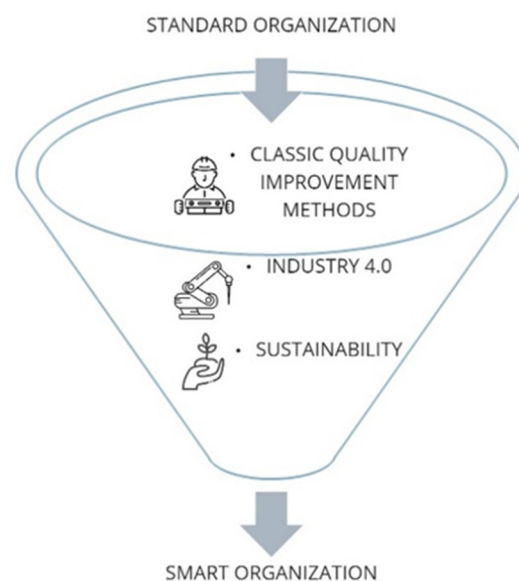


Figure 11. Theoretical transition from a standard organization to a smart organization.

There are also a series of limitations of our study, such as the fact that the analysis carried out regarding the phrase smart organization considered only the terms obtained related to this phrase, not taking into account other directly associated expressions.

Another limitation is that other factors could be included in the proposed solution such as organizational culture, resilience and adaptability, ethics and governance. The study highlighted an efficient and safe method for transforming a standard organization into a smart organization.

5. Conclusions

In this study, the attributes necessary to transform a traditional organization into a smart organization were identified and, using classic quality improvement methods, the framework for the digital transformation of organizations was implemented, as well as the processes monitoring, improvement and control using the Quality 4.0 application.

Following the implementation of the Quality 4.0 application, the main benefits were obtained:

- Continuous and real-time monitoring (the process monitoring ensures a rapid identification of indicators that need to be improved);

- Increased predictability (allow the prevention of critical problems related to the monitored indicators, thus reducing the costs associated with failure);
- Improved experience and increased awareness among employees regarding the important role they play in carrying out their daily tasks;
- Reduced operational costs (optimizing processes leads to a reduction in the costs associated with poor quality as well as increased efficiency);
- Developing appropriate actions in the organization that safeguard the environment by analyzing the Carbon Footprint and thereby protect the environment and support the achievement of the Sustainable Development Goals initiative.

With the emergence of the new technological discoveries, the focus moved on artificial intelligence (A.I.) elements; therefore, we plan to take it into consideration in future research to provide suggestions for completion within the application developed to generate ideas for improvements based on the eight principles and the suggestions related to them.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/su18157592/s1>, Tables S1–S5. Table S1. Results obtained; Table S2. Grouped keywords, Elsevier; Table S3. Grouped keywords, Springer; Table S4. Grouped keywords, Taylor and Francis; Table S5. Centralizer of key terms that define smart organizations.

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Abbreviations

The following abbreviations are used in this manuscript:

App	Software application
DMAIC	Define, Measure, Analyze, Improve, Control methodology
app UI	Application User Interface
CFP	Carbon Footprint

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