Adopting a Digital Transformation in Moroccan Research Structure using a Knowledge Management System: Case of a Research Laboratory

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***Abstract*—Digital Transformation has become one of the most discussed debates; many sectors have adopted digital transformation to gain a competitive advantage and to ensure their continuity. Moroccan universities, in their turn, are facing strategic and managerial challenges due to emerging practices related to digital transformation. To address this issue, the proposed work sets out to define the factors that lead us to adopt a digital transformation using SWOT analysis and to apply total quality management techniques to contribute to our research laboratory's digital transformation, by digitalizing and managing knowledge and processes. KMS-TQM digital platform has been used to capitalize knowledge and profile the different existing functions, positions, tasks, and referential competencies. Then, we analyzed all the actual processes to propose a business process re-engineering using Bizagi Modeler. The study's contribution is to standardize all the current processes in the laboratory to help the Doctoral Studies Center successfully carry out the digital transformation. Moreover, the aim is to make all functions and tasks for each position explicit.**

***Keywords*—Business process re-engineering; digital transformation; knowledge management system; Moroccan research laboratory; total quality management**

I. INTRODUCTION

Digital Transformation (DT) has recently increasingly driven organizations to change [1]. It has become one of the most discussed debates in business and organizational contexts [2]. The DT has involved sustainable management in coping with these changes; this is a vital and essential process for organizations that pretend to be leaders of change and be competitive in their sector [3], [4].

COVID-19 pandemic has mobilized research community for developing early diagnosis systems [5]–[11]. In addition, this pandemic has confirmed the need to digitalize public and private organizations (companies and educational institutions, etc.). The pandemic was an opportunity to innovate and accelerate the digital transformation to ensure the continuity and sustainability of the company [12].

In the education sector, the digital transformation has implicated sustainable management in dealing with these transformations [13]–[15]. The DT has been significant as a primary focus for higher education institutions (HEIs) [16].

Many studies have introduced the digital transformation in public administrations and the public sector [17], [18], that are focusing on redefining their processes to create new forms of public administration and interactions with users of their services.

In the current research, we will focus on the Moroccan research structures, taking as a case study our scientific research laboratory LaROSERI, which unfortunately requires additional efforts to ensure good productivity and sustainability. Through digital transformation, it will be able to manage efficiently and effectively the whole research laboratory from different axes: performance, knowledge management, and business process re-engineering.

In our previous work [19], we considered the research laboratory as a non-profit organization, and then we defined an indicator called "Global Laboratory Performance Indicator GLPI" to measure the laboratory's global performance. As a result, it has been shown a suitable approach should be adopted.

For this purpose, we suggest the following rankings, which show the necessity to rethink our managerial and strategic organization. To define the gaps that lead us to this study, we refer to the Ranking Web of World Research Centers as an initiative of the Cybermetrics Lab, a research group belonging to the Consejo Superior de Investigaciones Científicas (CSIC) [1]. CSIC is one of the leading essential research organizations in Europe. In 2006, CSIC comprised 126 centers and institutes throughout Spain. CSIC is attached to the Ministry of Education, and its primary goal is to promote scientific research to enhance scientific and technological progress.

The following Table I ranks the top ten research centers/labs, according to the 2019 CSIC ranking.

The Table II describes the global and African ranking of Moroccan research centers. As presented, the Moroccan Institute of Scientific and Technical Information - IMIST is ranked 65th in Africa and 4094th worldwide.

These rankings highlight the importance and the need for a set of actions to reposition the scientific research structures that are facing strategical and managerial challenges. Furthermore, Morocco upholds digital transformation through many initiatives to accelerate its development; we can cite some of them as described in the Table III.

[1] https://research.webometrics.info/en/

TABLE I. CSIC RANKING – 2019

Ranking	Institution	Country
1	National Institutes of Health	USA
2	National Aeronautics and Space Administration	USA
3	Centre National de la Recherche Scientifique CNRS	France
4	Max Planck Gesellschaft	Germany
5	Chinese Academy of Science CAS / 中国科学院	China
6	Centers for Disease Control and Prevention	USA
7	US Department of Veterans Affairs	USA
8	Consejo Superior de Investigaciones Científicas CSIC	Spain
9	National Oceanic and Atmospheric Administration	USA
10	Consiglio Nazionale delle Ricerche CNR	Italy

TABLE II. CSIC MOROCCAN RESEARCH CENTERS/LABS - AFRICAN RANKING - 2019

Global ranking	African ranking	Research Center/Lab
4094th	65th	Moroccan Institute of Scientific and Technical Information - IMIST
4198th	69th	National Center for Scientific and Technical Research - CNRST
4263rd	70th	Royal Institute of Amazigh Culture - IRCA
4529th	77th	Pasteur Institute of Morocco
5139th	90th	Scientific Institute of Rabat

TABLE III. MOROCCAN INITIATIVES

Moroccan Initiative	Description
"Horizon 2020"	In Morocco, the digital transformation has been accelerated, mainly due to the major government initiatives, "Horizon 2020", launched in 2017, and then "Horizon 2025", which have set ambitious goals in terms of e-government and training of young people in innovative technologies.
The National Plan to reform administration (2018-2021)	It is considered a crucial demand to upgrade the administration and the public Service through its restructuring and the reinforcement of its managerial and technical capacities to be qualified to offer good governance, ensure services of the general interest, and provide users with quality services.
The Framework Law 51-17	The Moroccan parliament approved the framework law 51-17 in August 2019, which concerns the government's strategic plan "2015-2030" to strengthen the national education system. The framework law 51-17 will mandate the creation of a national commission to supervise its execution and the overall education system reform in Morocco.

To properly define the factors that led us to this study, we propose a SWOT analysis as described in Table IV.

As shown in the SWOT analysis, it describes what the research laboratory excels, identifies in which it needs to undertake improvements to remain competitive. In addition, the analysis mentions factors that have the potential to harm the research laboratory or that could provide a strategic advantage to it.

TABLE IV. SWOT ANALYSIS

SWOT analysis	
Internal	
Strengths	***Weaknesses***
- The diversification of the theses topics, which emerge from several fields - Developing scientific and technical research in the computer sciences field - Offering different doctoral training and part-time teaching opportunities for PhDs - Collaborations between research teams, such as thesis co-supervision, and co-authors. - A good work atmosphere	- Insufficient dynamics of doctoral studies (doctoral theses duration are too often exceeding the regulatory period, which is three years) - Lack of a Digital workspace that can promote collaborative work - Insufficient resources (offices and materials) for the expected increase in the number of doctoral students enrolled. - Percentage of funded theses - Lack of using monitoring and steering tools (skills management, performance management, process management) - The absence of an internal structure specialized in setting up and monitoring theses, research projects, and research activities. - Lack of training to prepare PhD students for the job market actions (soft skills, coaching, personal development) - The need for a digital strategy - Lack of a quality management system - Lack of a digital tool to communicate research outcomes within the laboratory members - Lack of positions and skills repository - Integration of new information and communication technologies is relatively modest. - Lack of a digital system for monitoring and evaluating research activity - Lack of using efficient governance tools such as the BSC - Need for a management training, people in positions of responsibility
External	
Opportunities	***Threats***
- Research in collaboration with external laboratories, universities, or institutions. - Research projects in collaboration with CNRST, OCP, UM6P - Communicating research outcomes in different scientific events - Publishing scientific papers in indexed journals	- Absence of a digital platform - Concurrence with other national institutions - The absence of an alumni network - The gap between ambition and resources allocated to research - Weak private R&D and insufficient business/university interactions - Lack of sufficient anticipation of investments in IT/digital infrastructure

According to the points above, we have decided that adopting a digital transformation could solve this issue, thus digitizing, managing, and eventually repositioning the research laboratory within the university.

This work emphasizes using a knowledge management system (KMS) capable of filling all the gaps mentioned.

To successfully conduct this research, we focused on the following three research questions:

- How can the laboratory develop the digital transformation strategy?
- How clear does the management in the Lab understand the needs for a digital transformation of its organization?
- How does the laboratory apply digital technologies and managerial practices in its processes?

To answer the research questions, the main contributions of this work are the following:

- Defining the factors and limits that have forced us to adopt a digital transformation using the SWOT analysis.
- Using a Knowledge Management System that combines all the TQM aspects to manage the whole structure.
- Standardize all the research structure processes to be expressed explicitly.

The rest of this paper is structured as follows: Section II presents the related works and the problematic. Section III describes the proposed approach. Section IV shows the implementation using KMS-TQM digital platform and Bizagi Modeler. Finally, section V concludes the current work and proposes the perspectives.

II. Related Works

Due to new needs and requirements, several sectors have used digitalization to obtain a competitive advantage and ensure continuity [20], [21]. To discuss the state of the art, we propose the following subsections that determine each aspect of our work: Digitalization and Digital transformation, Knowledge Management, Business process Re-engineering, and their applications in the context of HEIs.

A. Digitalization and Digital Transformation

According to [12], the COVID-19 pandemic has confirmed the need and importance of digitalization in public and private organizations. It was an opportunity to innovate and accelerate the digital transformation to ensure the continuity and sustainability of organizations. To define the term 'Digitalization' and 'Digital Transformation', the following Table V illustrates some definitions proposed in the literature.

As pointed out in [25], digital competence is considered as a set of skills, knowledge, and attitudes necessary to use ICT and digital devices for responsibilities such as information management, and collaboration in an effective, efficient and ethical way. Digital transformation is considered a well-known topic at the moment, and ideas for digital products, facilities, and media were already widely understood in the 1990s and 2000s [26].

TABLE V. Digitalization and Digital Transformation Definitions

Ref	Definition
[22]	Digitalization is a "sustainable company-level transformation via revised or newly created business operations and business models achieved through value-added digitalization initiatives, ultimately resulting in improved profitability."
[23]	The digitalization is "the application of any digital technologies to all human activities, such as personal life, social, economic and political activities."
[24]	Digital transformation is "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies."

"Each organizational transformation implies a cultural transformation", the introduction of new technologies and digitalization has strongly contributed to the organizational and cultural transformation of companies [27]. Digital transformation has caused a significant change in the business, both in its activities, its organization and even in its culture [28]. Digital transformation is the integration of new processes within the company, such as adopting new technologies, tools, and work methods [29]. It impacts the global functioning of companies and transforms working methods and processes, requiring managerial approaches for a long-term vision to remain competitive, efficient, and modern [30].

B. Total Quality Management

Total quality management is a managerial approach that began in Japanese industry and has received increased attention in the West since the early 1980s[31], [32]. Total quality refers to a company's culture, attitude, and organization that attempts to consistently offer its customers products and services that fulfill their expectations [33].

TQM is a quality management approach whose target is to achieve ideal quality, the entire company should be mobilized and involved, by reducing waste as much as possible and by continuously improving the output elements [28]. Many agree that the TQM movement began in Japan, the term TQM comes from TQC, it was coined by A.V. Freignbaum, 1983 [34], [35]. Organizations that have successfully used the principles of TQM, have integrated the customer and quality into their business strategy [36]. It is the result of the efforts made to develop Quality Management.

Important aspects of TQM encompass quality management leadership and commitment, continuous improvement, rapid response, evidence-based actions, employee involvement, and a TQM culture [37].

In the context of higher education, several quality management models developed for use in industry have been involved in HEIs around the world [43], such as TQM, EFQM, Balanced scorecard, Malcolm Baldridge award, ISO 9000, Business process re-engineering and SERVQUAL. One of the most well-known quality management models that have

been implemented in higher education is Total Quality Management (TQM) as described in Table VI [44].

The study [45] defines the seven TQM factors as follows: Leadership, Strategic planning, Human resource management, Customer orientation, Process management, Information analysis, and Continuous process improvement. Through the implication of TQM concepts, assists organizations in learning strategies to increase productivity. The dimensions of TQM indicate the broad range of features in organizational cultures that promote innovation. Yet, the success of TQM demands an organizational culture based on trust and knowledge sharing [46].

TABLE VI. TQM APPLICATIONS IN HEIS

Ref	Year	Overview
[38]	2018	Through a review of the literature, this research aims to examine the impact of TQM on the organizational performance of Portuguese universities and polytechnic higher education institutions. The purpose of this study is to point out the importance of quality in education, specifically in HEIs, as indicated by the recent studies, the existing literature has highlighted the fact that educational institutions are lagging behind other organizations in terms of total quality culture.
[39]	2019	This research represents a survey done at two Swedish universities, and it attempts to determine teacher educators' use of digitalization technologies and the resulting demand for digital competence in higher education. Digital competence involves, among other factors, acquiring and familiarizing with various digital tools and apps to utilize Internet and digital technology is a critical and educative approach.
[40]	2019	The digital transformation strategy seeks to create the capacity to fully use the potential of new technologies in a fast and innovative manner in the future. The study proves that planning and implementing infrastructure allow all students and staff to effectively communicate, share information, and collaborate in research skills, thus improving teaching and learning and supporting administrative functions, students, and staff to use computer systems to boost their digital skills.
[41]	2020	This work represents a bibliometric of 1590 papers from the Scopus database. In the education sector, the Digital transformation has necessitated the implementation of a long-term management strategy. The authors conclude that HEIs are progressing in managing their economic, environmental, and social sustainability, concerning digital transformation to reach the model of an open, digital, innovative, and connected institution.
[42]	2022	Higher education institutions around the world have used numerous quality management strategies. As mentioned in this work, with the growing interest of the quality measures for sustained growth in education, the potential of developing a paradigm that reflects the challenges of higher education while including comprehensive quality and social responsibility ought to be considered. Therefore, the authors proposed an approach that connects the TQM and social responsibility of organizations and higher education institutions.

Recently, knowledge management by the company has constituted a sustainable competitive advantage, forming a common point with the objectives of the quality approach: obtaining a competitive advantage [47]. Not only knowledge management, but the implementation of business process management also helps organizations enhance their capacities through individual knowledge resources and greater collective knowledge of the organization.

The decision to manage the laboratory knowledge needs to set a standardized process by redesigning the actual processes. The following subsections define knowledge management and business process re-engineering.

C. Knowledge Management

Knowledge is a valuable, scarce and non-substitutable resource that enables an organization to gain a sustainable competitive advantage [38]. It is a set of experiences, values, information and ideas to assess and integrate new knowledge and experiences. Knowledge is an intangible attribute that is practically impossible to simulate and is considered a strategic asset that has to be effectively managed by every organization [48]. It can be explicit or tacit.

Knowledge management is the process of getting the right knowledge to the right person at the right time. Moreover, knowledge management aims to explicit the tacit knowledge by systematizing large sets of knowledge and gathering individual knowledge [49], [50]. The purpose is to produce valuable knowledge, fulfill the knowledge demands of customers, perform knowledge and innovations and strengthen the basic competitiveness of an organization [51]. The KM approach is the integration of individuals, methods and technologies implied in planning and implementing the infrastructure of the educational institutions [52].

Therefore, the process of knowledge implies four steps: creation, retrieval/storage, transfer and application [53]. The different components of KM as cited in these works [53] in Table VII include five elements:

TABLE VII. ELEMENTS OF KM

Knowledge Creation	The organization's ability to create and communicate knowledge in its services, and systems. The process of knowledge creation consists in capturing a part of tacit knowledge and transforming it into explicit knowledge.
Knowledge Application	The most important step in knowledge management is to ensure that knowledge is productively applicable for the organization's benefit, aiming to maximize performance.
Knowledge Sharing	Knowledge sharing is a range of behaviors that include sharing information or helping others to inspire innovative behavior.
Knowledge Capitalization (Storage)	It consists in identifying its crucial knowledge, preserving it and making it sustainable while ensuring that it is shared and used by the greatest number of people. Without this capitalization effort, collective knowledge does not exist.
Knowledge Transfer	It is the process of transferring knowledge between individuals, groups or organizations using various means or channels of communication.

D. Business Process Re-engineering – BPR

Today, quality is identified by the process approach of the activities. The management of processes is a strategy adopted by organizations that want to become more efficient; it would make them more efficient in executing their processes and ultimately more competitive [54]. The term of 'process approach' first appeared in its 2000 version: "the application of the process system within an organization, as well as the identification, interactions and management of these processes". This definition summarizes the requirements of a management system of quality, and treats the customer satisfaction by adding value to each process.

The process approach has been described and established as the quality management basis in organizations through the ISO 9001 version 2015 standard. It allows to identify, map the processes, and understand their interactions in an organization [55]. In addition, according to FD X50-176 standard, "Process management can be applied to all types of organizations regardless of their size, activity, and to the various management systems implemented (quality, safety, environment, etc.)"[56].

E. Use case: Research Laboratory LAROSERI

1) Description: The LAROSERI research laboratory was created in 2014. It belongs to the Computer Science Department in the Faculty of Science in El Jadida, Morocco. LAROSERI includes four research teams as described in Table VIII.

2) Challenges: The main objective of this study is to reposition the Chouaib Doukkali University in scientific research, by applying the Total Quality Management and using a Knowledge Management System. The SWOT analysis described in Table IV has determined the factors that led us to adopt a digital transformation. The Fig. 1 shows some Laboratory challenges.

Aiming to address these issues, we propose an approach based on Total Quality Management techniques that can provide adequate solutions to digitalize manage and steer the entire laboratory. The following section presents the proposed approach.

TABLE VIII. RESEARCH LABORATORY DESCRIPTION

Department	Name of the laboratory	Research Teams
Computer sciences	Research Laboratory in Optimization, Emerging Systems, Networks and Imaging (LROSERI)	Optimization, Intelligent System and Imaging
		intelligent transportation systems
		Business Intelligence, Network and Imaging
		Decision and Information Systems

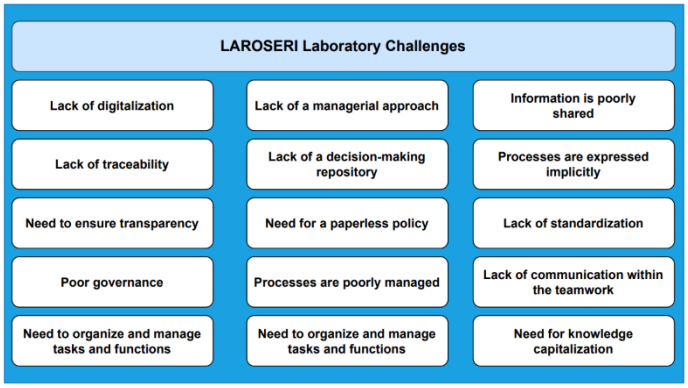

Fig. 1. Research Laboratory Challenges.

III. PROPOSED APPROACH

Related works have highlighted the potential that the TQM application in the research structure context offers. Our case study consists of proposing an innovative approach to properly digitalize and manage the research laboratory.

The proposed approach can be divided in the workflow as shown in Fig. 2. This digital transition impacts the overall functioning of companies and disrupts working methods and processes, which requires the use of managerial approaches for a long-term vision to remain competitive, efficient, and modern[57]–[59].

Fig. 2 and Fig. 3 describe the steps and tools that we used to adopt a digital transformation in our research laboratory.

A. Knowledge Management using KMS-TQM Platform

The knowledge management concerns the way knowledge is stocked and arranged. From a managerial perspective, the capitalization of knowledge is a major element in the improvement of performance via the establishing of a trustworthy resource base completed by appropriate software, and able to offer appropriate decision support. The objective of this function is to store relevant knowledge that assists actors in their operations [50].

In this work, we propose to use a KMS (Knowledge Management System) to capitalize and store knowledge in a repository, which is specifically designed for a scientific research laboratory, in order to provide relevant decision support to the different research laboratory's actors.

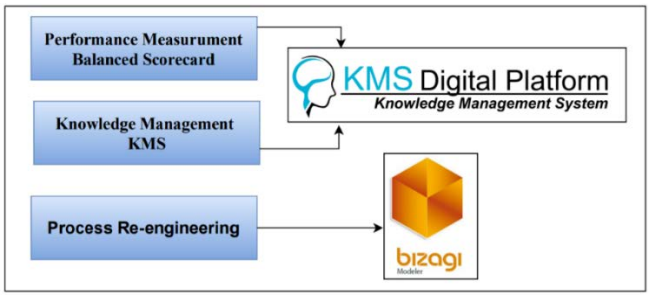

Fig. 2. Used Tools.

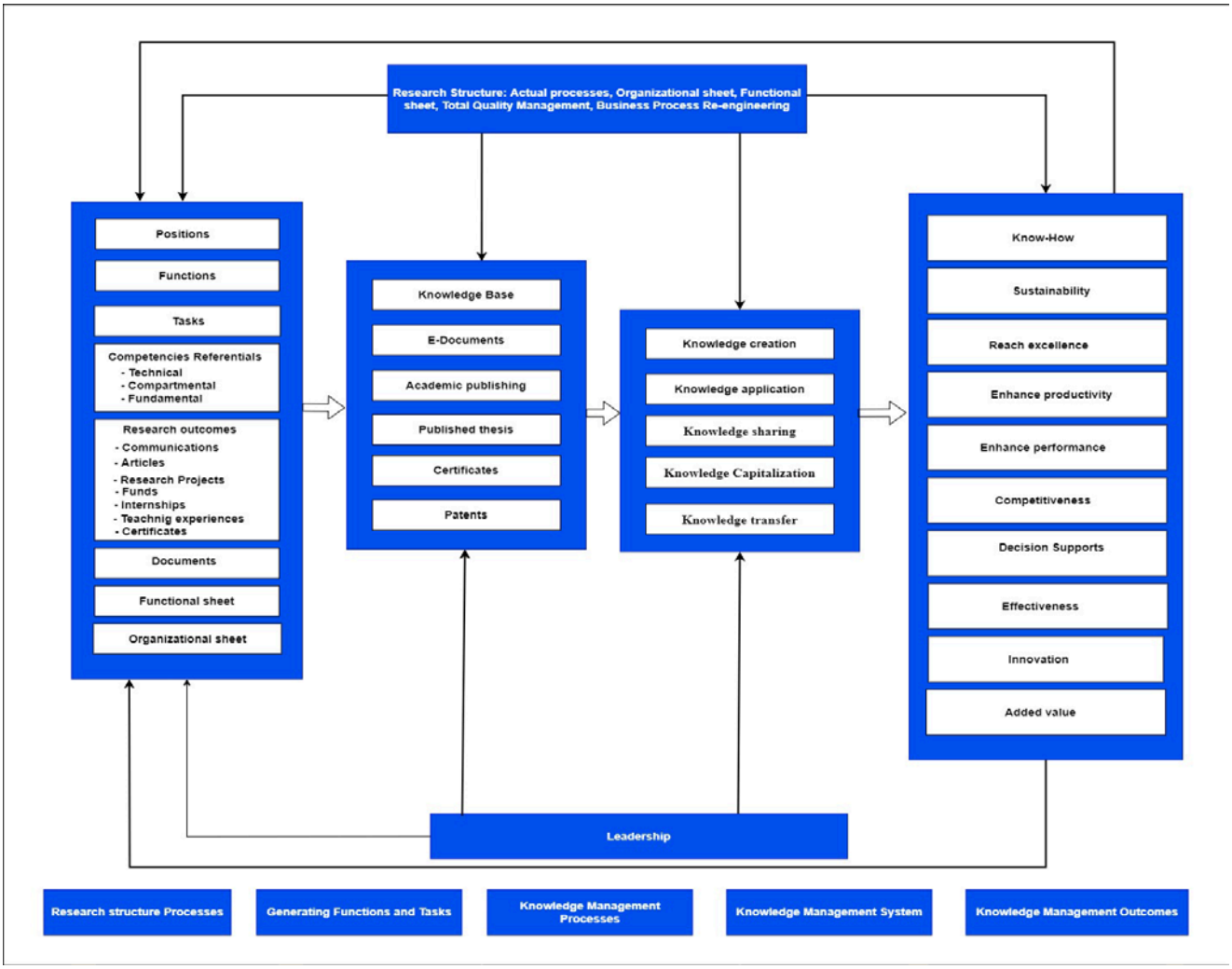

Fig. 3. Approach Workflow.

1) KMS-TQM digital platform: We are going to use KMS-TQM Digital platform[2,3] as described in the Table IX:

B. Business Process Re-engineering using Bizagi Modeler

Unfortunately, for Quality module, the platform offers only process mapping. Therefore, we chose the Bizagi Modeler tool for process modeling in order to make explicit all the existing processes within the laboratory. The choice of this robust process management tool aims to redesign the research laboratory process, thus integrating all actors, functions, tasks, etc.

Bizagi[4] is a free BPM tool (for a single user) to create, optimize and publish a process. It also provides a cloud-based collaboration environment, offering powerful and fast drag-and-drop design tools. In addition, it allows users to review process models from any location and on any device and to provide real-time feedback.

The KMS-TQM digital platform allows us the features shown in Fig. 4.

TABLE IX. KMS-TQM DIGITAL PLATFORM

KMS-Digital Platform	A facilitator and accelerator of digital transformation and CSR transition, thanks to its transversal approach focused on the company's business processes.
	A data collector and organizer, which prepares organizations for the next Artificial Intelligence revolution.
	A powerful and adaptable tool for steering (Balanced ScoreCard, dynamic dashboards) and monitoring (risk management, project coordination, etc.) all of the operational activities, and which has the capacity to integrate those of the stakeholders (via the integrated ISO 26000 and BCorp certification reference systems).
	With a strong digital component (digitalizing procedures, workflows, data collection), it will also support organizations in their technological transformation.

[2] http://37.187.48.129:9191/062021ic-canada-certified-trainings/
[3] https://masoda.ch/
[4] https://www.bizagi.com/en/products/bpm-suite/modeler

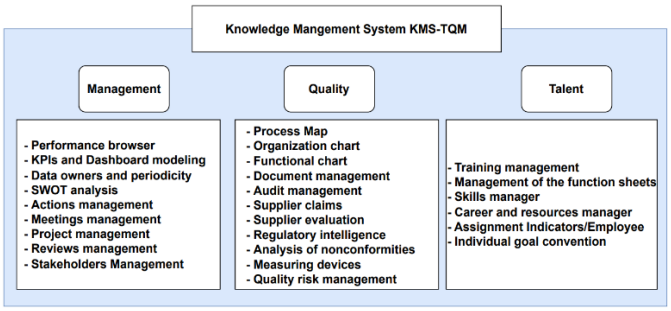

Fig. 4. Research Laboratory Digitalization and Management using KMS-TQM Digital Platform.

In this work, we intend to digitalize all the actual processes and make them as a standard in our Laboratory.

IV. Results and Discussion

In this section, we will apply the proposed approach, first by using KMS-TQM digital platform to digitalize and manage knowledge, then by using the Bizagi Modeler to manage the laboratory processes.

The purpose of capitalizing knowledge in our case–is to make explicit functions, tasks, and competencies. It answers the question: who did what and how?

By using the KMS-TQM platform, we generate the function sheets of each position in the research laboratory. We have assigned to each position a function(s) that is linked to numerous tasks and competencies.

The first step is to create the organizational entities and assign each to a parent entity. For instance, in our case, a doctoral studies center depends on the doctoral college as mentioned in Fig. 5.

The next step is to create competencies referential to tasks. Then, assigning each task to an appropriate function becomes possible, and defining the function first manager and assignments. Fig. 6-8 below illustrate the entity's management, tasks, and function management.

After preparing functions with their owners, the platform proposes to generate a functional or organizational sheet. It summarizes all the functions depending on their relationship. Fig. 9 describes an example of the functional sheet.

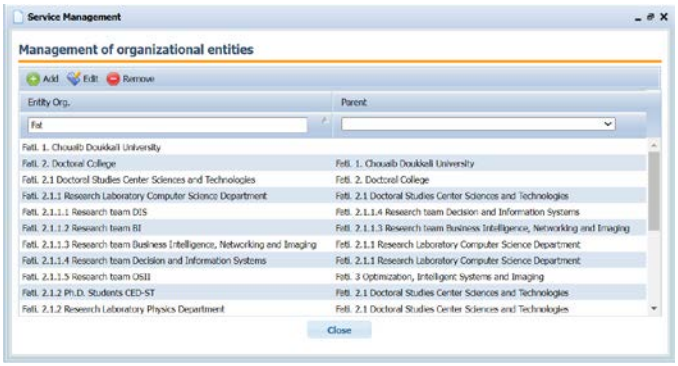

Fig. 5. Entities Management.

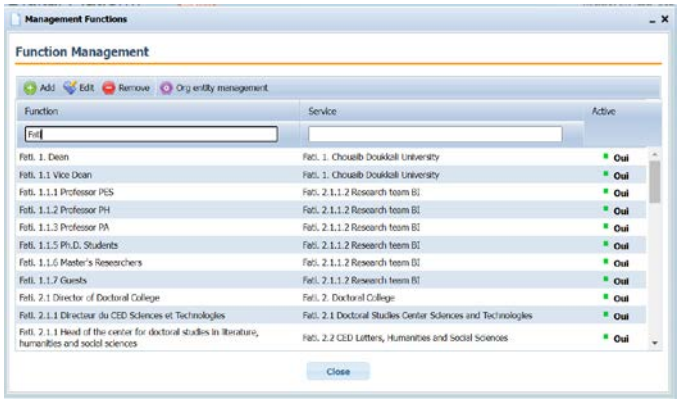

Fig. 6. Functions Management.

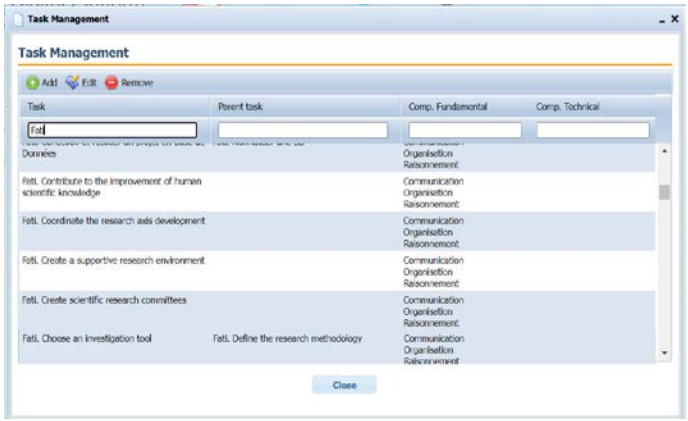

Fig. 7. Tasks Management.

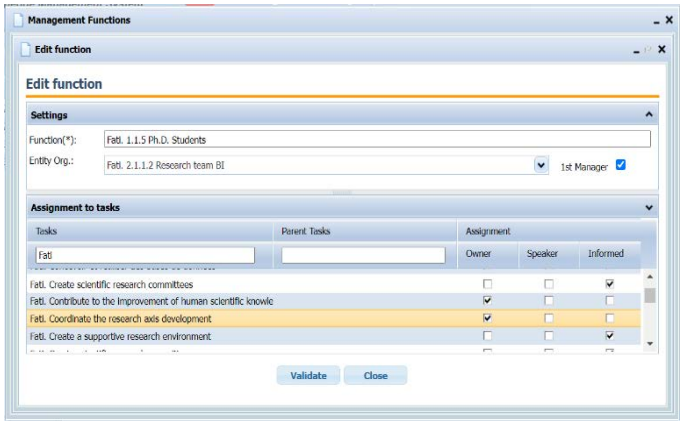

Fig. 8. Affecting Tasks to Function.

To set standardized processes within the Laboratory, each actor should elaborate a draft of the different activities; it concerns the laboratory chief, the research supervisors, research teams' chiefs, PhD students. After these tasks, the Director of the CeDoc (Center for Doctoral Studies) collects information concerning each process, capitalizes knowledge, redesigns the actual processes, and finally, validates, and standardizes these processes.

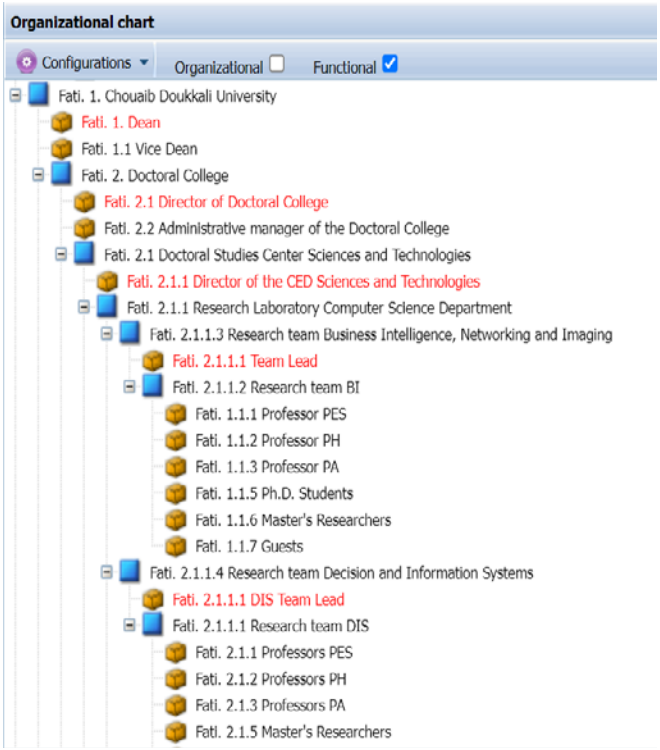

Fig. 9. An Example of a Functional Sheet.

Fig. 10 and Fig. 11 depict this activity and the different interactions.

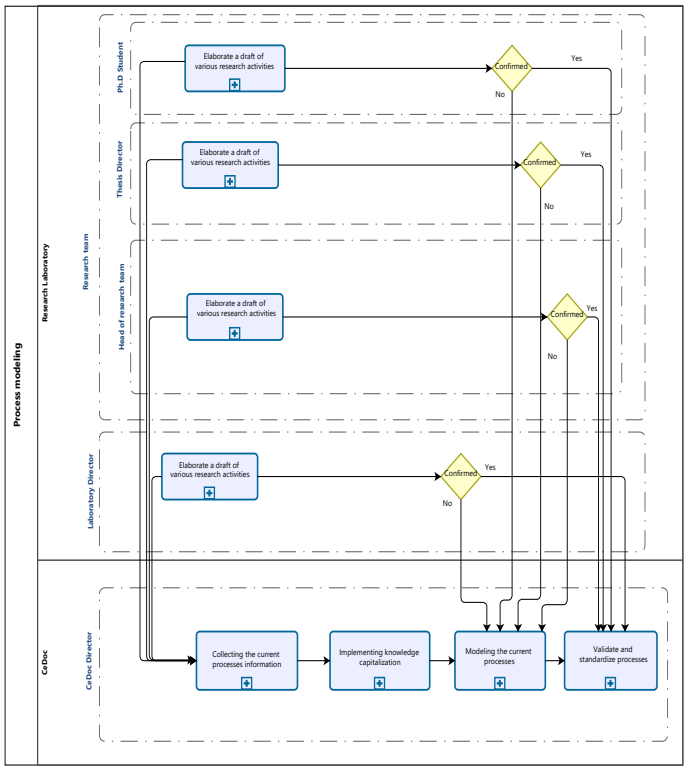

Fig. 10. Research Laboratory Processes Re-engineering.

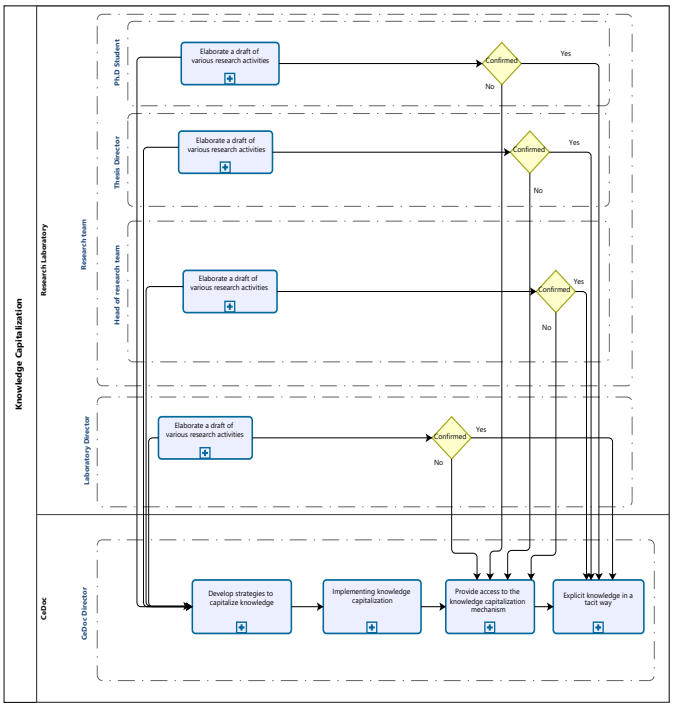

Fig. 11. Research Laboratory Knowledge Capitalization.

V. Conclusion

In summary, the TQM applications aiming to digitalize and manage research structures are still very weak. This paper analyzes the factors to adopt a digital transformation in the research laboratory by applying the SWOT analysis and gives an overview of some available recent studies that apply this approach in the same context. The main objective of our research is to integrate a Knowledge Management System and apply TQM aspects, which can apply to any research laboratory that desires to adopt a digital transformation. The proposed approach briefly describes the steps to be followed to digitalize and manage knowledge and redesign the current processes.

Despite the advantages of the research approach, some limitations can be addressed through future research; the platform used in the implementation does not link process modeling with other modules, which means integration issues. Therefore, to propose a suitable and adaptable solution, it will be more practical to think of an open-source solution with huge possibilities.

In future work, as mentioned, we intend to conduct a comparative study between laboratory management information systems (LIMS) by selecting specific criteria to propose an adequate digital framework. The framework will combine the quality management system (QMS) aspects and integrate innovative solutions to digitalize and manage research structures.

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