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ASSESSING BPM'S ROLE IN A DIGITAL INNOVATION PROJECT

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Master thesis presented as partial requirement for obtaining the Master's degree in Information Management

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by

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ABSTRACT

The world is changing. In the digitalization era, digital devices are everywhere, enabled by the quick proliferation of smart and connected products. The transformation we are witnessing is not only about the new digital artefacts, but also includes the alignment of the operations, business processes, strategy and organizational, and IT structures, resulting in the so-called maturity. Although it might not be trivial, this increased efficiency is closely connected with the processes, of how to create opportunities for optimizing and redesigning them. However, the combination of digital innovation and business process management, and how one benefits the other, is not very explored in the literature, which constitutes a research gap.

Given this, the importance of business process management practices and their relationship with the remaining organisation's dimensions was studied and assessed through a comprehensive and systematic literature review. Hence, insights were gathered to create a framework that allows answering the research question "W*hat is the BPM's role in a digital innovation project*?". It was expected to understand the challenges associated with digital transformation, what core requirements are the most valuable, and what is the role of process management in all of it.

A focus group has confirmed the usefulness of the artefact, by showing the correlation between the different elements in scope and allowing an understanding of the capabilities needed in the organisation. Nonetheless, the feedback suggested the adaptation of the framework to include a maturity assessment pre-stage and cost evaluation per digital transformation category, so it can be completely transversal to all types of organisations and all budgets.

KEYWORDS

Business Process Management; Digital Innovation; Process-Awareness; Design Science Research

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LIST OF ABBREVIATIONS AND ACRONYMS

AI	Artificial Intelligence
BIM	Building Information Modelling
BPM	Business Process Management
BPMN	Business Process Modelling Notation
BPR	Business Process Reengineering
COPD	Chronic Obstructive Pulmonary Disease
CPS	Cyber-Physical Systems
DSR	Design-Science Research
DT	Digital Transformation
DT&I-BPM	Digital Transformation and Innovation with BPM discipline
EA	Evolutionary Algorithms
ESS	Event Streaming System
HMW	How Might We
IoT	Internet of Things
IPA	Intelligent Process Automation
IS	Information Systems
IT	Information Technology
KPI	Key Performance Indicator
LSS	Lean Six Sigma
ML	Machine Learning
NLP	Natural Language Processing
OM	Operations Management
PoPM	Process of Process Management
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
QV4M	Quantitative Verification for Monitoring
RPA	Robotic Process Automation

SME	Small and Medium Enterprises
SNA	Social Network Analysis
TQM	Total Quality Management
USA	United States of America
XP	Extreme Programming

1. INTRODUCTION

1.1. CONTEXT

The world is changing. We are now at the golden age of digital innovation, where technologies like social media, cloud computing, analytics, and big data, wearable devices, 3D printing, and intelligent autonomous systems turned to be part of our everyday routine, either in our personal or work life (Fichman et al., 2014). Given this, one can say that digital devices are everywhere (Mendling et al., 2020), enabled by the quick proliferation of smart and connected products which are feeding billions of sensors used for tracking and monitoring (Zhang, 2016). However, when talking about digital transformation, one is not only referring to objects and artefacts, but also to the inherent facilitation of the processes (Mendling et al., 2020). In what concerns enterprises, digitalization is recognized by the alignment of their operations, business processes, strategy, and organizational and IT structures, while improving responsiveness, flexibility, and agility (Holotiuk & Beimborn, 2017). This increased efficiency measure comes with the change the world is witnessing, which is directly connected with the processes, meaning that it is not possible to understand one without the other (Langley & Tsoukas, 2016). Mendling et al. (2020) give some examples like Uber and Netflix: people did not change the concept of moving from one place to another, or watching TV. What changed was the process of finding a ride and paying for it, or the process of choosing what to watch and when to do it.

At this point, it is known that, if managed correctly, digital innovation allows greater speed, higher quality, and lower costs, by working on deviations from the original process to find a functional and more efficient solution. This transformation would be improved by adding Business Process Management (BPM) to the equation, which would allow the creation of opportunities for optimizing and redesigning the existing processes (Mendling et al., 2020).

BPM is about managing and improving processes in an organisation, to obtain the most suitable outcomes, and create value for the enterprise. Part of BPM's concept, according to Dumas et al. (2018), includes "*gaining competitive advantage through innovation*". This idea is the link and motivation to explore the alliance between the opportunities provided by digital technologies, where new business models, products, and services are generated (Berger et al., 2018), and the capacity of managing it all with a clear objective in mind through BPM.

1.2. MOTIVATION AND PROBLEM IDENTIFICATION

There is an interesting metaphoric statement, made by Mendling et al. (2020) which translates the importance of this work's topic: "*The world is blazing with change and digital innovation is fuelling the fire. Process management can help channel the heat into useful work*". It means that both digital innovation and process management have advantages on their own, but the result of one benefiting the other brings much more valuable outcomes. There are nonetheless cases where this natural synergy is not being explored, neither by the companies nor by the scientific community (Mendling et al., 2020), which creates a limitation, thus resulting in the loss of opportunities for today's world.

In this sense, as previously mentioned, companies are focused on the adoption of emerging digital technologies to create new market opportunities and to increase their competitive advantage.

However, the way they manage those changes with their existing business processes is not well defined in the literature (Gross et al., 2021; Mikalef & Krogstie, 2020). This constitutes a research gap that Grisold and Stelzl (2021) unfolded into three research directions: "*exploring the role of BPM in digital innovation*", "s*coping digital innovation activities within BPM initiatives*" and "*aligning organizational structures to realize digital innovations through BPM*".

All the three directions mentioned before are valid for the problem definition. The situation that is being detected is related to the possible wrong management of digital technologies combined with BPM, and so the intersection of these approaches needs to be explored on a deeper level (Van Looy, 2017). Companies are aware of the benefits that BPM and digital innovation can bring by themselves separately, being facilitators for improvement and change (Van Looy, 2017). However, technologies nowadays seem to be applied without a defined strategy and quick solutions appear instead of digging deeper into the problem (Van Looy, 2021). This situation constitutes a motivation for the present research. Some questions were already posed in literature, like what is the real difference between "*an innovation carried out with and for digital technologies*", "*how to implement digital innovations within the IT department*" (Ciriello et al., 2018), "*what is the explanation for the current state of play"* (Van Looy, 2021). It requires adaptations at various levels and the impact is seen in business activities, customer and business models, and business processes (Gebayew et al., 2018).

Given this, it is necessary to further explore how BPM can be properly integrated into a digital innovation project, using existing and disruptive technologies to promote a positive impact on the transformation of the organisation itself and its associated methodologies and processes. In section 1.3 the research question and the objectives proposed are presented.

1.3. Research Question and Objectives

Given this context and the problem identified, the research question for the presented work is: "*What is the BPM's role in a digital innovation project*?"

To answer it, the following objective was defined: *"A framework to use BPM in a digital innovation project".* For a more detailed approach, this objective is unfolded into 6 intermediate objectives:

1. Identify companies' core requirements for a successful digital transformation process.
2. Identify the advantages of using BPM in a process-oriented firm.
3. Assess the role of processes within companies' digital innovation projects.
4. What are the most relevant management methodologies for process improvement?
5. Propose a framework for the use of BPM philosophy in a digital innovation project.
6. Validate the framework.

By finding a suitable strategy to incorporate BPM in a digital innovation project, the output answers the proposed research question, thus promoting value creation in organisations. This study's relevance and importance are detailed in section 1.4.

1.4. STUDY RELEVANCE AND IMPORTANCE

The present study intends to explore the link between BPM and digital innovation nowadays. This relation has already been acknowledged in literature (Schmiedel & vom Brocke, 2015), however, it is still an underdeveloped topic (Rosemann, 2014; Van Looy, 2021). Digital process innovation is becoming an organisation's day-to-day challenge, and it is evolving so rapidly that is not possible to define a decision-making strategy that completely supports the organisation's activities and goals. The world is witnessing an "*accelerating transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities of digital technologies and their impact across society in a strategic and prioritized way*" (Gebayew et al., 2018). Thus, by achieving this work's proposed objective, it is expected that the outcome contributes to an understanding of the current state of BPM in digital innovation projects, so it can be further developed and applied in different sectors, consequently bringing new overviews and advantages for society, enterprises, and scientific community.

From the perspective of the scientific community, the major goal is to share the knowledge, so that new findings and opportunities can be pursued. To understand how this interplay between BPM and digital innovation can be applied in different sectors, science still needs to experience a variety of models and theories to be validated (Rosemann, 2014). Furthermore, and as stated by Van Looy (2021), in response to the increasing demand for innovation, several forms of BPM have been created as quick solutions, instead of deeply exploring the topic. Given this, the author proposes the creation of a practical decision tool to complement the work already developed around the topic of digital process innovation, where worldwide insights were collected, and conclusions generalized for all sectors.

Following the author's suggestion, a way to develop the mentioned decision tool is by applying Design-Science Research (DSR). Building a new framework or adjusting an existing one, would not only benefit the scientific community, but also companies and their employees, adding the fact that results in Information Systems (IS) field have been shown to create an impact on economical and societal levels (vom Brocke et al., 2013). Furthermore, the topic in the study cross-links people (their tasks, knowledge, skills), processes, and systems. So it is no longer a matter of having the best technologies around, but to encourage new talents from diverse disciplines to engage in the demand for more explorative BPM research, in an "*outside-in"* strategy (Rosemann, 2014). This will contribute to a more open society, where ideas and insights are globally shared, and to workers' motivation. Having motivated collaborators promotes the companies' development and growth through better results, making new tools and digital innovations available to the market, which increases the global economic activity.

2. METHODOLOGY

The present work is focused on a specific problem, for which a solution was proposed. This solution is represented by a framework to be built; thus, it can be called an artefact.

According to Hevner A. et al. (2019), Design Science Research (DSR) has been very used in IS studies in the past 2 decades, and its purpose is to achieve the desired goals, by contributing to the knowledge of how things are designed. DSR implemented in a research project allows for the structure and arrangement of new innovative artefacts, which can be either constructs, models, methods, or instantiations (Hevner et al., 2004; Peffers et al., 2007).

Given this, the DSR methodology is aligned with the objectives and structure of the present work and so it will be followed as described in the literature by Peffers et al. (2007).

2.1. DESIGN SCIENCE RESEARCH METHODOLOGY

DSR is commonly used in IS and it is categorized as a more proactive type of research since design science aims to "*extend the boundaries of human and social capabilities by creating new and innovative artefacts*" (Hevner et al., 2004). Nonetheless, with the application of DSR, it is possible to contribute to both the research (theoretical) and the practical component of a digital innovation project (Hevner et al., 2019).

This methodology includes a global framework and allows the creation of a mental model so readers can understand the stages of the development and be capable of following the topic and evaluating its results (Peffers et al., 2007). The main steps proposed by Hevner et al. (2004) and Peffers et al. (2007) are the following: problem identification and motivation, the definition of the objectives for a solution, design, and development, demonstration, evaluation, and communication.

However, for this work's purpose, the developments proposed by Hevner et al. (2004) and Peffers et al. (2007) were adapted to the five steps represented in
Table 2-1.

Step Number	Step Description
i.	Problem Identification and Motivation
ii.	Objectives Definition
iii.	Design and Development
iv.	Evaluation
v.	Communication

Table 2-1 – DSR Methodology adapted from Hevner et al. (2004) and Peffers et al. (2007).

i. Problem Identification and Motivation

This step involves the definition of the research problem, where the value of the solution is justified. By doing this, the researcher and the audience will be motivated to pursue the solution and accept the results. Another accomplishment is the fact that it enables people to understand what the researcher's interpretation and reasoning of the problem were (Peffers et al., 2007), thus leading to a perspective that can differ among the audience.

ii. Objectives Definition

After the problem is identified, one must define the objectives for a solution, which can be made through the knowledge of what is realistically feasible and also through the knowledge of the state of the problem and current solutions, when they exist. This allows us to think rationally and in the proper context when inferring the objectives (Peffers et al., 2007).

iii. Design and Development

The next step is the design and development of the artefact (which can be constructs, models, methods, or instantiations). To achieve this stage there should be a deep knowledge of the theory that can be put into practice to result in a solution. First, one must determine what is the desired functionality of the artefact, followed by the definition of its architecture and ending with the artefact's creation (Peffers et al., 2007).

iv. Evaluation

This phase consists in assessing if the solution created is aligned with the primary objectives defined, meaning that it should solve one or more instances of the initial problem. This can be made through a variety of methods, such as functional comparison, results of satisfaction surveys, client feedback, or simulations (Peffers et al., 2007). The outcome can be of two types: if the result was positive and a proper solution was found then the process moves forward to the last step (**v**); if on the other hand, the solution proposed is not compliant with the expected effectiveness, then a new iteration is made, thus going back to step **iii**.

v. Communication

Finally, with the results aligned with the objectives, formal communication is presented to the scientific community in the form of a research publication/paper (Peffers et al., 2007).

2.2. Research Strategy

As previously mentioned, DSR will be applied to the present work. The strategy to be followed was already mentioned in chapter 2.1 in its general terms. In this chapter, it is presented an in-context explanation of each step.

i. Problem Identification and Motivation

To identify a problem and the motivation to solve it, one should look for a hidden literature gap about ways to improve processes in a digital innovation era, which for this work's purpose is translated by the research question: "W*hat is the BPM's role in a digital innovation project*?". Both the problem identification and the motivation were already described in chapter 1.2.

ii. Objectives Definition

The objectives defined for this research are described in chapter 1.3. In the present section, the same intermediary objectives are represented in a table format to detail which method and instrument will be applied for its completion (Table 2-2). This objective's structure can be seen as a guide to creating the framework that will answer the research question posed in chapter 1.3.

Objective	Description	Method	Instrument
1	Identify companies' core requirements for a successful digital transformation process.	Literature review	Scientific papers
2	Identify the advantages of using BPM in a process-oriented firm.	Literature review	Scientific papers
3	Assess the role of processes within companies' digital innovation projects.	Literature review	Scientific papers
4	What are the most relevant management methodologies for process improvement?	Literature review	Scientific papers
5	Propose a framework for the use of BPM philosophy in a digital innovation project.	Literature review	Scientific papers
6	Validate the framework.	Qualitative research	Focus group

Table 2-2 – List of the research intermediary objectives and their respective methodology to be applied.

iii. Design and Development

The design and development phase includes the framework construction (artefact). This will be designed based on a comprehensive literature review to explore the main concepts related to ways of process improvement, followed by a systematic literature review about BPM and Digital Transformation, where key learnings and the main research articles are retained. As a result, the main insights are collected and used in the framework's construction.

iv. Evaluation

For the framework's evaluation, qualitative research will be performed, namely focus group, to assess the usability of the framework. For this step, the appropriate contexts should be chosen to obtain valid results. Since the topic is much more technical, expert people in the related fields should be approached to share their insights regarding the applicability in different realities and sectors. Given this, and for a first iteration, 3 people will be chosen: a Design Thinking expert, a process mining expert, and an RPA expert.

v. Communication

This research will be released to the scientific community, to share the knowledge acquired during the process and also to make it available for further investigation.

2.3. Focus Group

The use of the focus group technique has been increasing as a qualitative research tool and evaluation tool (Sim & Waterfield, 2019). It consists of a discussion between various participants, where the researcher has the role of moderating the flow of the discussion (O.Nyumba et al., 2018). Some agree that its concept is can be described as something between a meeting and a conversation, since it is an event organized beforehand with a specific objective, but it also has space for spontaneous contributions (Sim & Waterfield, 2019).

For the insights collected through the discussion, it is important to have into account the group dynamics and interaction, to understand the context of how things were said, so then one can communicate it clearly, without misunderstanding. Furthermore, asking for consent for the recording and for the use of the data collected is mandatory at the beginning of each session (Sim & Waterfield, 2019), since intellectual assets (opinions, knowledge, ideas) will be used for research work which will go public. Another aspect of focus groups is that the participants have the right to choose anonymity before providing any information, and it is the researcher's responsibility to behave accordingly.

3. LITERATURE REVIEW

3.1. DIGITAL TRANSFORMATION

3.1.1. Concepts

Digital Transformation (DT) can be generically defined by the changes motivated by the use of digital technologies, in society and industries (Agarwal et al., 2010). However, technology is not the only aspect that contributes to this phenomenon. Vial (2019) was able to develop a definition for DT, through other existing concepts present in IS literature. He defined DT as "*a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies*". These elements together can promote innovation and increase performance, while organisations end up controlling fewer elements of their operating environment (Vial, 2019). The combination of these elements and their application within the organisation's strategy, structure, processes, and culture, results in a very complex system (Vial, 2019). If properly aligned with the company's goals and direction, it allows organisations to remain competitive and discover new ways of creating value (Svahn et al., 2017) in the current digital world. In this context, Sousa & Rocha (2019) stated that DT can occur when organisations start to be prepared, not only for receiving new technology, but also to adapt and embrace social changes within the company, namely, social learning techniques, knowledge sharing, and the concept of communities of practice.

3.1.2. Areas

To be digitally transformed, is not just about using technologies and their tools, but it is about the change in the organisation's strategy (Shahi & Sinha, 2020) and the dynamic interactions between the firms and their environment (Vial, 2019). During the last four decades, the world has been experiencing the effects of turning the internal organisational processes more digitized (Fichman, 2004), and IS researchers try to identify what are the unique aspects of this digitization phenomenon applied in areas like industry and in specify organisational domains or product families (Agrawal et al., 2013).

Nowadays, digital transformation can take many forms. Some of the most known technology-enabled forms are process automation and process intelligence techniques, such as Robotic Process Automation (RPA) and Intelligent Process Automation (IPA). These technologies, among others, are considered process automation methods, which are closely related to digital transformation, since they can also create conditions to improve processes in a variety of forms (either by reducing cycle times, or reducing costs, etc). These topics are going to be further developed in more detail in the following chapters.

3.1.3. Challenges and Opportunities

Due to the quick expansion of DT, companies almost did not have time to prepare a strategic reorganization regarding the structure and technological adaptations. This creates a challenge and a specific mindset to get aligned to the new DT reality. A study conducted by Andersson and Rosenqvist

(2018), explores the digitalization challenges associated with the question of reorganising the company. The authors describe ten challenges that are a rap up from meetings and discussions with both global suppliers to perform digital transformation and with companies that are transforming themselves. These conversations were conducted through different levels of DT: technology, user-centrism, business model-related issues, and strategic issues. Regarding technology, the challenges have to do with managing platforms and big data, and concern the user orientation situation, for instance, when referring to big data analysis (Andersson & Rosenqvist, 2018). The managerial challenges are connected to business model related issues, like the creation of bilateral cooperation or the establishment of partnerships associated with a wide form of cooperation between a set of organisations (Andersson & Rosenqvist, 2018).

However, the management of DT should not be considered only an intra-organisational or operational issue, but yes, an issue whose scope includes the strategic and societal environments, to which the highest priority should be given. Implications may arise: some related to the pressure on internal organisational structures, others concerning the reorganisation of processes and resources. Sousa & Rocha (2019) reinforce these topics, pointing out the potential change in job positions, where the search for more automated and accurate tasks constitutes a big game changer. According to Markowitsch et al. (2002), digital was the greatest motivator for the creation of new customer segments, market volatility, the great impact of the internet on an organisation's core business, and cultural diversity in a global marketplace. In short, the areas that constitute the main challenges are the following: change management, internal culture, and organisational structures and processes, customer orientation and customer-oriented work practices, new skills and internal capabilities, and the leadership challenge (between hierarchical top-down approaches and open collaborative environments) (Andersson & Rosenqvist, 2018).

On the other hand, these challenges also come with opportunities. Opportunities can have a very positive outcome if organisations manage themselves in the right way, developing skills towards the new trends, thus helping to sustain value inside the company and promoting growth among the various hierarchical levels (Sousa & Rocha, 2019). Besides this, opportunities can also be process-related, like in logistics and manufacturing processes. For this, DT brings higher control, made remotely and in such a digital way, that data flows across factories, thus optimizing and improving processes (Mähring et al., 2018). Other opportunities reside in the new products and services improved with sensors and labeled as "smart", due to their capability of capturing the customer use patterns, thus increasing the product's performance. New opportunities are rising every day, and they come to transform the business as we know it, having an impact on a wider spectrum of action, new kinds of services, new pricing models, and new business models (Porter & Heppelmann, 2014).

3.1.4. Digital Innovation

As presented in the previous chapters, digitalization requires many changes, at various levels. An important one is the integration of digital innovation practices into the company's workflow (Nambisan et al., 2017).

By the eyes of Ciriello et al. (2018), digital innovation means "*innovating products, processes, or business models using digital technology platforms as a means or end within and across organisations*".

The characteristics of these platforms are convergence and generativity (Yoo et al., 2012), where the first is translated by putting many features together in the same artefact, whereas generativity means to be able to expand the artefact's capabilities. As a result, the outcome of digital innovation is the enablement of distributed innovation and combinatorial innovation (Yoo et al., 2012). Distributed innovation includes the combination of knowledge from different sources, thus flowing inward and outward between firms, with the business goals leading the way (Chesbrough & Bogers, 2014). This means that the organisational boundaries are becoming more permeable, thus allowing a knowledge-sharing wave across companies, consumers, and society. Combinatorial innovation results in many different combinations of digital technologies, by converging existing modules with sets of capabilities and features already existing (Yoo et al., 2012).

The process of innovation has been seen as linear and sequential, applied in consecutive phases. Some authors divided the process into various steps, for instance, discovery, development, diffusion, and impact (Fichman et al., 2014), or into idea generation, advocacy & screening, experimentation, commercialization, and diffusion & implementation (Desouza, 2011). These processes have the conditions to originate digital innovations. However, to go further, organisations must support combinatorial and distributed innovations (Yoo et al., 2012), which allows the creation of many possible combinations of digital technologies, thus resulting in various open-ended innovation opportunities.

To exploit digital innovation opportunities, Heinz D. et al. (2021) suggested organisational resilience as a way to overcome the posed challenges. The authors describe organisational resilience as *"an organisation's ability to remain successful by undergoing adaptive or transformative processes when facing challenges and adversity"*. Furthermore, this characteristic also implies that the organisation turns more flexible when unexpected challenges arise, being aware of threats, thus allowing the business to grow through DT and business model transformation (Heinz et al., 2021). In their study, Heinz D. et al. (2021) concluded that to be successful in a DT process, digital innovation plays a critical role, together with organisational resilience.

Given this, one can conclude that digital innovation is supported by digital technologies, even if indirectly, since it "*involves the continuous matching of the potential (or capabilities) of new and/or newly recombined digital technologies with original market offerings*" (Nambisan et al., 2017). Thus, digital innovation can be seen as a temporary set of problem-solution pairing, involving user/business/industry needs, digital artefact features, and environmental and trends conditions.

3.2. BUSINESS PROCESS MANAGEMENT

3.2.1. Concepts

Regarding Business Process Management (BPM), Dumas et al. (2013) define it as "*a body of methods, techniques, and tools to identify, discover, analyse, redesign, execute, and monitor business processes to optimize their performance*". BPM has been evolving into a very well-established set of principles, by joining knowledge from Information Technology (IT), industrial engineering, and management sciences (Dumas et al., 2013; Van der Aalst, 2013). Nevertheless, to understand how BPM is performed, it is first necessary to explore the concepts involved. Starting with business process, it is defined "*as a* *collection of inter-related events, activities, and decision points that involve a number of actors and objects which collectively lead to an outcome that is of value to at least one customer*" (Dumas et al., 2013). Given this, a process is composed of events and activities, which in turn are composed of tasks. An event has no duration and by occurring, it may trigger one or more activities. These last ones are limited in time and require the execution of some action (Dumas et al., 2013). Furthermore, there are the decision points, which are relevant to the process's outcome. Depending on the path that is followed in a given decision point, the result can be affected in two ways: can either be positive (when value is reached) or negative (no value added). In addition, as part of the process there are actors involved (can be human or an organisation, for instance), physical objects (like documents, and materials), and informational objects (such as electronic documents) (Dumas et al., 2013). To have a visual idea of how the process is structured and which changes or corrections would make sense for a given situation, it is possible to represent a simplified version of it through a model. This model uses a modelling language, i.e., BPMN (Business Process Modelling Notation), which is constituted by vocabulary, syntax, semantics, and notation, just as a common language (Dumas et al., 2013). The vocabulary includes the activities and events, which were already mentioned, adding the gateways (important for the decision-making along the process) and sequence flows.

BPM is derived from the Business Process Reengineering (BPR) development, whose methodology improves processes, and it might potentially lead to the improvement of defined Key Performance Indicators (KPIs). These are performance measures of a universe of four performance dimensions: time, cost, quality, and flexibility, and it is the first step for the analysis and monitorization of process efficiency and process automation (Chakraborti et al., 2020). KPIs are defined by the organisation beforehand according to the objectives proposed and the resulting value is then put against the standard one to evaluate whether the process needs adjustments/corrections or not. To achieve good process performance, it is necessary to manage the relevant work in the organisation, while focusing on the processes that are running. The most usual pattern is to focus on time and cost measurements, and this happens because it is difficult to standardize, optimize, implement and generalize the flexibility and quality measures (Chakraborti et al., 2020). However, it is important to right balance the measurements applied to check the process performance, according to the desired business goal and outcome.

In a literature review conducted by Gross et al. (2019), the authors concluded that most of the methods applied in BPM are used for incremental process improvement, and only a few showed approaches for more radical changes. These last ones are the ones that imply some organisational disruption (Davenport, 1993), thus having a higher probability of resulting in innovative behaviours. In another study conducted by Kerpedzhiev et al. (2021), it was shown that for delivering a higher value and contributing to corporative success, BPM capability areas must be updated considering how digitalization is occurring. From this, it is understood that the most used BPM methodology is not bringing innovation and major changes in the industry. For this reason, some authors defend that BPM should be more opportunity-driven (Grisold et al., 2019), even if it implies a redevelopment of the methodology to explore the opportunities together with digital innovation. This brings new challenges for the companies, mainly the question of how to promote digital transformation while adapting their existing business processes and setting the alignment of their vision and goals.

3.2.2. BPM Life Cycle

The stages of a BPM life cycle are represented in Figure 3-1 and described below:

- **Process identification**

The process identification phase starts with a business problem. To find the business processes that are posing the operational problems, a *process thinking* event has to take place in the organisation. This involves the identification of the relevant processes for the problem, so then their scope can be delimited and the relations between processes identified. This results in a process architecture which is afterwards used to choose one or more processes to be managed during the remaining lifecycle phases. To help with the problem identification, it can also be measured the performance of the processes, like for instance, the waiting time or error rates (Dumas et al., 2013).

- **Process discovery (or As-Is process modelling)**

After choosing the relevant processes, their current state is documented through process modelling (Dumas et al., 2013). This means that the process is rationally built according to the specifications discussed in the previous cycle phase, demonstrating how the process is currently working (Pan & Zhang, 2021). The resulting model will then serve as a base for the following cycle phases.

- **Process analysis**

The process analysis phase consists of analysing each process and detecting the potential issues on the As-Is model for further documentation and quantification through performance measures (if possible). By the end of these activities, the result is a list of issues, whose resolution is afterwards prioritized based on impact and effort estimation (Dumas et al., 2013).

- **Process redesign (or process improvement)**

In this stage, the aim is to take on the issue list that resulted from the process analysis, and to redesign those same processes to allow the organisation to meet its performance goals. This generates an internal cycle between the new proposed changes to the process and their immediate analysis through specific techniques, where only the most promising ones are integrated into the process redesign outcome: the To-Be process model (Dumas et al., 2013).

- **Process implementation**

After the To-Be model is finished, the next step is to implement it in the organisation. For doing it, different changes must occur to convert the model from "paper to reality": organisational changes and automation (Dumas et al., 2013). The first one is related to the way people work and perform tasks. However, process management has more to do with automation, whose focus is on the development and deployment of IT systems that give support to the future situation.

- **Process monitoring**

After the implementation of the new redesigned situation, the performance has to be measured by collecting and analysing data from the process. This includes, for instance, deviations from the expected behaviour, errors that will be subjected to correction, or even new issues (Dumas et al., 2013) that have not been detected at the beginning of the iteration. From this point on, the cycle can be repeated as many times as necessary, until the performance goals are achieved.

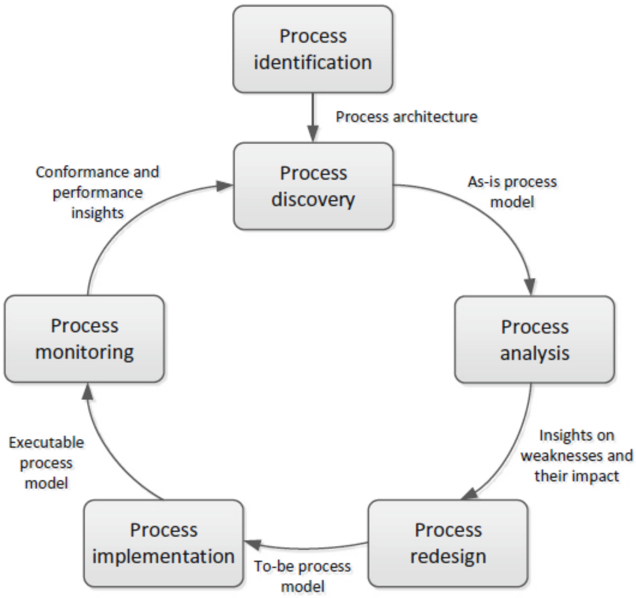

Figure 3-1 - BPM life cycle representation (Dumas et al., 2013).

3.2.3. Process Improvement

Improvement is defined as "*the act or process of making something better; an addition or change that makes something better or more valuable*" (*Definition of Improvement*, n.d.). Thus, to improve, one can take different actions, but with the same expected outcome – to create value. In this sense, processes are transformed and/or automated, and the methodologies to do it are guided by different disciplines.

Some examples of other disciplines to improve the organisation's operational performance are Total Quality Management (TQM), Operations Management, Lean, and Six Sigma (Dumas et al., 2013). The main focus can be on products and services, managing the physical and technical functions (like production and manufacturing), eliminating activities that do not add value, or minimizing the defects along the process. Some of these practices are described in the following chapters (3.2.3.1 and 3.2.3.2).

3.2.3.1. Process Transformation

- **Lean**

Lean is a management discipline that comes from the Toyota Production System (manufacturing industry). Lean philosophy is to do more with less (e.g., less human effort, less equipment, less time), by eliminating the activities that promote waste in production processes while maximising customer value. This action allows for higher effectiveness, increased profit, and more flexibility (Satoglu et al., 2018).

Regarding its approach, Lean management does not include IT and the principles and tools it proposes are Just-in-Time, Jidoka, teamwork, waste reduction, and continuous improvement (Liker, 2004). Some of those were later absorbed by the BPM methodology (Dumas et al., 2013), which then emphasised the use of IT. In sum, Lean is all about efficiency and speed and ensuring that the right activities are being performed (Laureani & Antony, 2019).

- **Six-Sigma**

Six Sigma was originated in the United States of America (USA), within the Motorola Research Centre, and its methodology is focused on data-driven process improvement (Laureani & Antony, 2019), aiming for a business performance without errors. To achieve it, Six-Sigma tools follow a performance model known as Define-Measure-Analyse-Improve-Control (DMAIC), whose description is the following (Pyzdek & Keller, 2003):

- *Define*: to define the goals of what needs to be improved;
- *Measure*: to measure the current system;
- *Analise*: to analyse the system while trying to identify actions to eliminate the gap between the current performance and the defined goals;
- *Improve*: to improve the system;
- *Control*: to control the new resulting system.

This methodology focuses on improving customer value and efficiency, allowing the organisation to make more money. For this, the quality should also be improved by producing better products and delivering better services, in a faster and cheaper way. As a result, waste is reduced and the organisations can focus on customer requirements while preventing defects to occur, reducing cycle time, and saving money (Pyzdek & Keller, 2003).

- **TQM**

TQM, as already mentioned in a previous chapter, stands for Total Quality Management, often defined as a "*holistic management philosophy*" (Dahlgaard-Park et al., 2018). As indicated by its name, this approach is focused on the quality of products, by sustaining and improving them, and on the quality of services (Dumas et al., 2013), exceeding customers' expectations.
TQM has principles and techniques that should be applied in one's daily working life, by creating the necessity of building a mindset of continuous training, gathering the right motivation, and applying specific attitudes (Dahlgaard-Park et al., 2018). The most used principles are the following: customer focus, leadership, people engagement, process approach, improvement, evidence-based decision-making, and relationship management (*QMP 2020*, n.d.). By incorporating the mentioned ISO principles in the company's strategy to achieve improvement through a transformation process, one will be on the right path to lead the organisation to efficiency.

- **Operations Management**

According to Reid and Sanders (2019), Operations Management (OM) is a business function dedicated to functions like planning, coordination, and resources control, to assure the manufacturing and

delivery of the products and services a company produces. Given this concept, one can understand OM as a management and core function of every company.
Like TQM, Six-Sigma, Lean and other methodologies not mentioned in the present work, OM is also an approach for process transformation whose goal is to create value. Business productivity can then be measured by the value-added, meaning, the difference between the value returned and the value of the inputs (Reid & Sanders, 2019). Principles to apply this methodology are waste reduction and the efficient performance of the activities, resulting in the reduction of their costs, thus increasing competitiveness.

3.2.3.2. Process Automation and Process Intelligence

- **Robotic Process Automation (RPA)**

Over the last decade, business processes automation has been developed, not exclusively, due to the concept of Robotic Process Automation (RPA) (Chakraborti et al., 2020). This is software for automating tasks within a process. Usually, these tasks (or chains of tasks) are repeated several times, and it can be very time-consuming to perform it, also increasing the probability of adding errors to its execution. This kind of mechanical work (e.g., copying data from one screen to another) can then be substituted for automation, helping organisations to reduce costs and to increase process scalability (Dumas et al., 2013).
Regarding methodology, RPA uses an "outside-in" approach, meaning that the system does not need to be redesigned, so the existing information systems remain unchanged. The only thing that changes is who executes the tasks, and this is answered by the replacement of humans with agents (van der Aalst et al., 2018). Furthermore, it is expected that the RPA software adapts to changes in the electronic forms of information systems when the key content remains the same; this behaviour is similar to what humans would do. Given this, RPA could be another way for adding value to a process, making it more efficient and less time-consuming, mainly for simple and mechanical tasks, which do not require human interpretation (Agostinelli et al., 2020).

- **Intelligent Process Automation (IPA)**

As it was previously understood, RPA could be useful when tasks are part of the routine and are repetitive. However, when the scenario is more complex and requires human interpretation and decision making, one has a more appropriate technology available, which is the case of Intelligent Process Automation (IPA). This is defined by Tuttle D. (2019) as a class of tools that results from the combination of Artificial Intelligence (AI) with automation and customer data, and its focus is on adapting RPA technology to work on more complex workflows without human intervention (Naveen Reddy et al., 2019). To do this, IPA must be configured with a combination of business rules, decision criteria, and determination logic, allowing for pattern detection which leads to a final automated decision (Naveen Reddy et al., 2019).

- **Workflow Automation**

Workflow Automation is used to design, execute, and automate business processes. While RPA focus on automating individual tasks that repeat themselves several times, workflow automation is dedicated to automating the flow of a set of tasks that are part of a process using software and guided by the rules previously established (*Workflow Management Coalition*, 1999). This technique allows to reduce human errors and improve the business process efficiency, which is done by automating the tasks that were already pre-defined by people (Goyal & Singh, 2021).

- **Process Mining**

Process Mining consists in collecting all the available event data (logs) for posterior analysis. This action allows a journey composed of discovery, monitorization, and process modelling, with the final goal of improving them (Van Der Aalst et al., 2011). Process mining capabilities include various tools (Figure 3-2), namely, process discovery, conformance checking (i.e., finding deviations to a specific process model), construction of simulation models done automatically through the logs, extending them, or editing them. Furthermore, with process mining, is also possible to do predictive recommendations based on historical data (Van Der Aalst et al., 2011).

To have better visualization and monitorization of the processes, one of the process mining tools is the presentation of automated and interactive dashboards, which can then be explored among the various granularity layers (from managers to analyst level) (Dumas et al., 2013). Some platforms (e.g., Celonis) allow the users to create their dashboards from scratch, defining personalized KPIs and the proper visual aggregation of data (tables, circular graphs, etc).

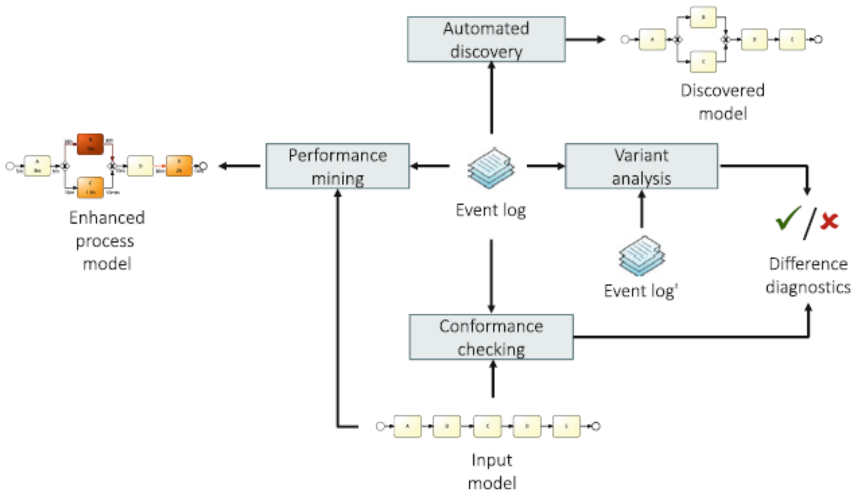

Figure 3-2 – Process mining techniques diagram (Dumas et al., 2013).

3.3. Systematic Literature Review on Digital Innovation and BPM

The comprehensive literature review performed in chapter 3, was a tool to introduce the relationship between BPM and digital innovation. It presented necessary concepts, methodologies, their applications, and some of the current trends in the field. Given this, it was possible to collect a lot of information from a variety of sources. To filter some of this information, and select the most relevant studies, a systematic literature review is performed.

This systematic literature review will be developed using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) methodology. PRISMA is used to guide the reporting of systematic literature reviews in a transparent way (Page et al., 2021).

3.3.1. Method

This dissertation's goal is to create a framework that allows us to understand how BPM can be applied in various types of digital innovation projects. To have guidance through this process, three research questions were formulated (Table 3-1).

RQ1	What technologies are currently being used for innovative BPM?
RQ2	Which innovation core requirements are related to processes?
RQ3	How can transformation promote process improvement?

Table 3-1 – Research Questions (RQ) generated for the systematic literature review.

As was previously mentioned, PRISMA allows to filter of the information, resulting in the most relevant articles. Given so, one must define the level of detail to apply. To do so, Table 3-2 was created with some keywords and their respective synonyms (titles). The concepts associated with these keywords were already explored in chapter 3.

Regarding the keywords' choice, it was intended to join "process innovation" to the expressions deck, however, it could not be represented as a synonym of "process improvement", since one cannot assure that innovation will lead to improvement (despite that being the goal). When "process innovation" was simply added to the keywords list and applied in the research string, the results were null. This might mean that there is still not much information about this topic on how to improve processes by being digitally innovative.

Given their multidisciplinary nature, not all the concepts were included in the search string because they would increase the risk of enlarging the scope. Examples are the management disciplines for process transformation (e.g., Lean, Six-Sigma) and Automation.

Keywords	Title
Process Improvement	Process Transformation
BPM	Business Process Management
Technology	---

Table 3-2 – Keywords and respective synonyms used for the systematic literature review.

The query string generated from Table 3-2 was the following:

("BPM" OR "Business Process Management") AND ("Process improvement" OR "Process transformation") AND "Technology").

This query string was applied in three search resources, namely, Scopus, Web of Science, and IEEE Xplore. This last one has more technical content, compared to the first two which are more general database, which allows for broadening the typology and content of the information. The three resources used are reflected in Table 3-3.

Resources	Domain
Scopus	https://www.scopus.com/
IEEE	https://www.ieee.org/
Web of Science	https://www.webofknowledge.com/

Table 3-3 – Resources and respective domains consulted for the systematic literature review.

When applying the string in the resources, should be chosen the option of looking up its terms in the abstracts, titles, or keywords of the articles. This guarantees that the selection will be very specific for the defined domain. The search should also be refined by applying inclusion and exclusion criteria (Table 3-4), that is, to consider only scientific documents dated before January 22th, 2022, and after the year 2016 (inclusive), thus increasing the possibility to have the most recent topics. Furthermore, the exclusion criteria defined were to not consider articles that are not in English, that report reviews and overviews, or that are non-academic papers.

Inclusion Criteria	Exclusion Criteria
Insights on how BPM can contribute to digital innovation initiatives, while improving the processes.	Documents published before 2016
	Other language that not English
	Review/overview articles
	Non-Academic papers (e.g., newspapers, magazines)

Table 3-4 – Inclusion and exclusion criteria applied to the preliminary search through the query string in each of the resources.

After applying the exclusion criteria directly in the search filters of the three chosen domains, the resulting articles are screened by their abstracts to refine the search. For this, duplicates are removed, together with articles without abstract or books. Moreover, also articles whose focus is not related to process improvement facilitated through digital innovation technologies/methodologies were excluded.

3.3.2. Results

A total of 146 documents were obtained (corresponding to identification phase according to PRISMA nomenclature – Figure 3-3) directly from the three databases used (Table 3-3).Since this is much less than what was expected (around 300 - 500 results), one can think that either the keywords were too specific, hence limiting the scope, or there is still not much information about the topic.

Nonetheless, the process moved forward to the abstract screening phase. Step 1 consisted of removing the duplicated articles (n = 29), and also articles with no abstract (n = 0), articles where was not possible to have access (n = 6) and articles whose publishing date is before 2016 (n = 64) were removed, resulting in a total of 99 excluded documents.

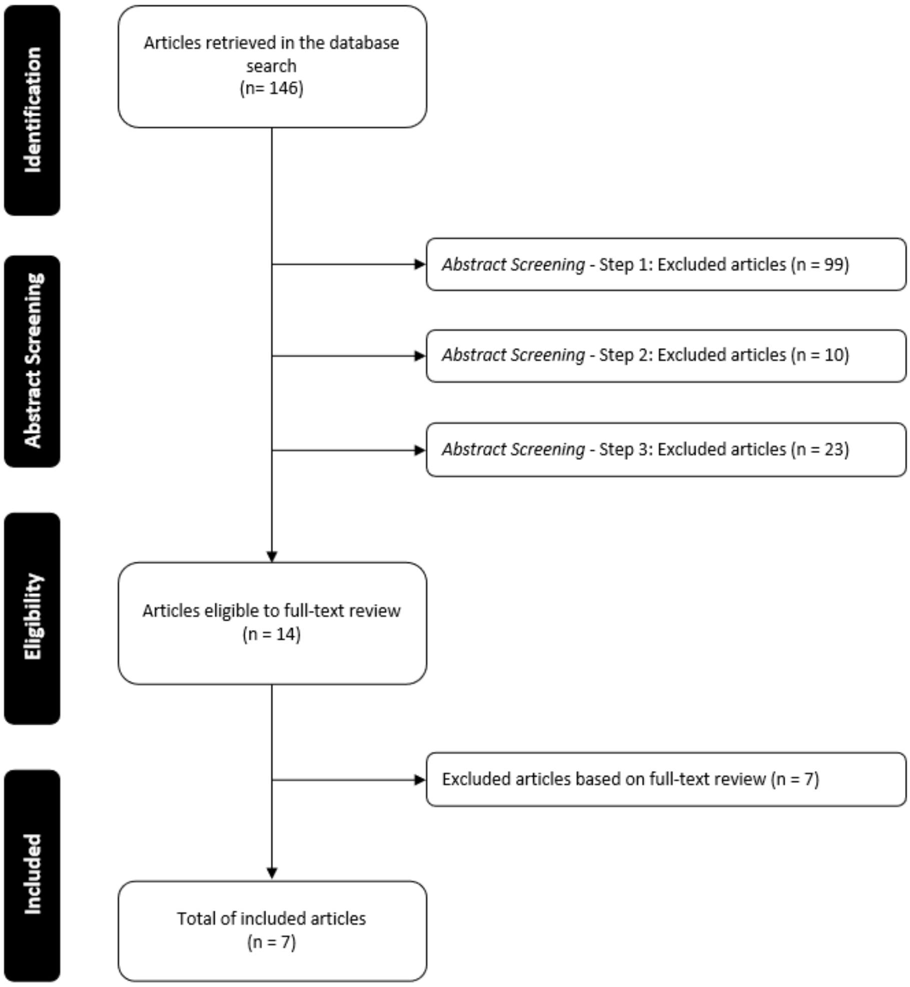

Figure 3-3 – PRISMA flowchart.

In step 2 the exclusions consisted of removing the articles whose language was not English (n = 4), removing overviews or systematic revisions (n = 4), and removing books and book chapters (n = 2), hence resulting in a total of 10 excluded documents.

In step 3, a total of 23 articles were excluded due to their non-relevant and out-of-scope abstracts, such as software tools for process modelling, the use of process reference models focused in DT, competitive BPM strategies and decentralized BPM. Given this, the remaining 14 articles were considered eligible to be further analysed in the full-text screening phase.

In this phase, the 14 articles were fully analysed, and 7 articles were excluded due to their non-relevance for the present study, where it was understood that the focus was the improvement of business models, without focusing on innovation through digital transformation.

Given this, 7 remaining articles were considered eligible to perform the systematic literature review on BPM and digital innovation (Table 3-5), since they present effective solutions that relate the phases of the BPM cycle to digital transformation activities.

Tupa and Steiner (2019) point out some BPM benefits, which include quality improvement, cost reduction, the alignment with the aspects of the organisation, among others.

Document Title	Authors	Source Title	Publication Year
Design it like Darwin - A value-based application of evolutionary algorithms for proper and unambiguous business process redesign	Afflerbach, P; Hohendorf, M; Manderscheid, J	Information Systems Frontiers	2017
Design thinking and process transformation: Synergy of these approaches	Vasilieva E.V., Tochilkina T.E.	CEUR Workshop Proceedings	2020
Exploiting Internet of Things for Business Process Improvement	Stoiber C.	CEUR Workshop Proceedings	2021
Improved patient journeys: ERP transformation and the radical deployment of process management across 500,000 nursing days at Hirslanden	Kuhn T., Bruhin J., Hill T.	CEUR Workshop Proceedings	2019
Industry 4.0 and Business Process Management	Tupa, J; Steiner, F	Tehnicki Glasnik - Technical Journal	2019
iPRODICT - Intelligent process prediction based on big data analytics	Mehdiyev N.; Emrich A.; Stahmer B.; Fettke P.; Loos P.	CEUR Workshop Proceedings	2017
Value-Driven Robotic Process Automation (RPA): A Process-Led Approach to Fast Results at Minimal Risk	Kirchmer M., Franz P.	Lecture Notes in Business Information Processing	2019

Table 3-5 – Articles considered for the Systematic Literature Review conducted in the present research.

The authors describe how to effectively combine BPM with Industry 4.0, pointing out the phases of the BPM cycle where Industry 4.0 can bring innovation by digitally transforming the business. Starting with the process redesign phase, the authors refer to the industry 4.0 technologies as enablers of process digitalisation, which in the context of industry 4.0, is related to smart factories or digital supply chain networks (Tupa & Steiner, 2019). The main goal of this step is the creation of an enterprise digital model, facilitated by computational intelligence, for instance, to define the support processes, the autonomous control processes, to define the main processes, and to define the relationship between the cyber and physical layer (Tupa & Steiner, 2019). The authors refer to the automation of business processes, which can be engaged by digital factories and by the application of Cyber-Physical Systems (CPS). These CPSs allow both the simulation of processes using digital twins (useful for process monitoring) and also allow the implementation of data acquisition and data processing elements, machine-to-machine communication, and human-machine interaction, thus enabling the creation of an environment for process implementation (Tupa & Steiner, 2019). The Internet of Things (IoT) technologies can also contribute to the process monitoring phase of the BPM cycle, since it helps in the automation of real-time process monitoring systems, thus displaying the processes status, and enabling data to be stored in data warehouses (which can lead to big data analytics) (Tupa & Steiner, 2019). Through the monitorization of KPIs and big data analysis, it is possible to identify hidden patterns, trends, and unknown correlations, among other relevant information that helps in decision-making and that helps in process improvement. Also, Stoiber (2021) identifies IoT technologies as important agents in process transformation (process redesign, according to the BPM cycle), whose outcome is much more than a process improvement. This can be achieved through digitalization and its integration into the workflows. Despite of being ongoing research (PhD project), the author believes that IoT creates value when integrated into business processes, with a well-defined orientation and a suitable toolset.

As stated by Kirchmer M. et al. (2019), new digital tools have the capability of leveraging the process transformation, thus leading to higher efficiency, and agility, enhancing customer experience, and improving the overall quality. Among these digital tools, the authors include RPA in the group of transformation enablers approaches. However, the RPA application might not be suitable for all processes; RPA might be able to transform processes, by automating them, but when wrongly applied, it might not bring any improvements. Therefore, Kirchmer M. et al. (2019) propose an approach to identify what can be automated, and in what conditions. For the present work, the focus is on the application of RPA in the process implementation phase of the BPM cycle, promoting the automation of processes, thus contributing to digital transformation and innovation. To achieve this, one should first analyse the high-impact business processes in their As-Is state by, for instance, evaluating if there are unnecessary roles or functions, how is the cycle time affected and what is affecting it, and if the existing software systems are still considered useful (Kirchmer & Franz, 2019). The second step is to examine which process components are prepared to be automated, where the idea is to select repetitive tasks with no need for human judgement. Kirchmer & Franz (2019) also point out the contribution of process mining approaches, so the process analysis can also be automated itself. With the resulting insights, the To-Be process is designed by including the new automated and value-driven activities. To complement the mentioned procedure, the authors' advice an agile strategy to allow a fast value realization (Kirchmer & Franz, 2019). Given this, the authors present a methodology that combines RPA with a process management discipline (Agile) and process mining approaches, applied to the BPM cycle (process implementation and process analysis phase, respectively), that ends up delivering value by possibly reducing costs, reducing the cycle time, increasing efficiency, and creating innovation.

Also concerning process mining's contribution to process improvement, Kuhn et al. (2019) explored how BPM technology was useful to standardize and optimize the internal processes of a hospital group, and whose transformation resulted in an innovative solution by improving the group's internal processes. In this article, the authors describe the process mining technology as a useful tool to apply on 4 particular phases of the BPM cycle: process discovery, process analysis, process redesign, and process monitoring. The inherent digital transformations are process intelligence, automation, and process optimization. Regarding automation, process mining enables the identification of the parts of the processes that could be automated (corresponding to the BPM cycle phase of process analysis), mainly in tasks that include information collection with manual delivery (in the context of a hospital environment) (Kuhn et al., 2019). Furthermore, the authors refer to process mining as a useful technology to increase the type of improvements that could be made, thus discovering new opportunities to innovate. This is done by gathering the information from various data sets, and then going through the functionalities of process discovery and conformance checking. Hence, it would be possible to identify risks and support the continuous process improvement also enabled by process intelligence technology (Kuhn et al., 2019). This transformation enabler is also useful for improving processes, by removing unnecessary activities, detecting bottlenecks, and quickly responding to detected events. Finally, the authors point out another advantage of this technology, which is the monitorization of the processes, done by extracting the information from data sets, then cleaning raw data, and continuously monitoring the end-to-end process, according to the defined KPIs and risks that were already identified (Kuhn et al., 2019). Despite these notes focusing on technology, the scope of this transformation was not limited to it. It also included organisational changes, people, and roles readjustment, and was complemented by the integration and alignment of all of them, as capability areas (Reijers & Mansar, 2005). Furthermore, and in the context of these organisational changes, the process implementation was enhanced by the application of the Agile methodology, which involved a series of sprints and multidisciplinary teams to put them into practice.

From another perspective, Vasilieva & Tochilkina (2020) present a case where design thinking was used to redesign processes, which in some cases might lead to a digital transformation. The end of this transformation is found to be the start of a continuous improvement cycle, where for each iteration, business process innovation might occur. However, this outcome will depend on the results, context, and transformation steps. Given this, the authors describe the following stages of process transformation: goals definition, process design, test of the new process, analysing test results, new process implementation, and analysis of the results (Vasilieva & Tochilkina, 2020). For redesigning a business process, it is necessary to define a variety of factors such as functions/roles, information systems, particular important events, automation technology (if applicable), and automation strategy, among others. Design Thinking was shown to be an efficient methodology to return a new innovative product, which in this case is an improved business process. Its methodology includes the following steps (briefly indicated): formulation of the main problem's question, identification of strategies to remove barriers between the AS IS and the TO BE states, the definition of KPIs, and hypothesis testing (Vasilieva & Tochilkina, 2020). By diversifying the background of the team participants, it promotes different ideas and more creativity, thus allowing a faster-pace development. With this, processes can be improved by acting in the corresponding stage of the BPM life cycle (process redesign), promoting process optimization and connection between teams, creating awareness for risks/opportunities.

Another approach that contributes to process improvement is described by Afflerbach et al. (2017), who identified a research gap in the computational support for business processes redesign to generate innovative ideas. The authors describe how to apply Evolutionary Algorithms (EAs) to design efficient structures and, at the same time, to keep the momentum of continuous improvement going. Given this, the algorithm was designed with the vision of the solution enabler in mind (computational intelligence) and considering BPM requirements as the problem domain. The authors' approach consisted of an analogy between the BPM cycle and the reproduction cycle in nature: the identification/ discovery phase corresponds to natural selection, the analysis phase corresponds to sexual selection, the redesign phase corresponds to reproduction, and implementation/ monitoring & controlling phase corresponds to offspring (Afflerbach et al., 2017). The steps that followed this approach were the representation of the process components, the representation of the process design, the customization of the EA (tailoring the initial population, defining the type and number of selection and reproduction mechanisms), and the generation of the initial population. After this, the EA continues its cycle through the reproduction phase, until it reaches the defined termination criteria: can either be by reaching a defined number of generations or by reaching a specified number of generations without alteration of the best design found (Afflerbach et al., 2017). After evaluating the EA solution, Afflerbach et al. (2017) concluded that its application develops more realistic processes, by mimicking the human decision-making approach, with the particularity of avoiding personal biases and subjectivity. Given this, this paper presents itself as an important contribution to the present work, by showing how computational intelligence contributes to innovation when applied to the BPM cycle for business processes redesign.

Mehdiyev et al. (2017) developed a predictive enterprise software for the control and management of both business and operational processes in real-time. The focus was on the application of IoT predictive and prescriptive analytics technologies to enable process optimization and process discovery, thus improving decision making. Regarding process discovery, the authors adapted the logic of process mining technology to formulate a data mining system, through data collected by the sensors. These data have to be processed, aggregated, segmented, and condensed into log information (Mehdiyev et al., 2017), which implies a robust data transformation (to process instances) to derive accurate data models. Furthermore, insights from quality control were added to the business process model formulated through the activities logs of the A-to-Z process, and the resulting variants were identified. From this step forward, the authors compute some metrics, measure aspects of the models' similarities, and derive implications and suggestions against the initial reference model. Hence, at the same time the prototype is promoting process discovery improvement, it is also contributing to process redesign enhancement, by combining machine learning, complex event processing, and mathematical optimization. With this, Mehdiyev et al. (2017) present a system that is leveraging the potential of IoT technologies to improve processes by data driven real-time optimization. This is done through error prediction used as input for post-processing step predictions and meta-heuristic optimization approaches (genetic algorithm methods). The authors concluded that the integration of analytics should first deliver proof of its robustness and accuracy, so then it can be automated into the business process. Furthermore, the integration of these technologies should include a human judgement that serves as input to the models, rather than used as adjustments to the output (Mehdiyev et al., 2017).

The summary of the findings that resulted from the 7 previously described articles is represented in Table 3-6.

Digital Transformation Categories		BPM Cycle Phases: Process Discovery	Process Analysis	Process Redesign (Improvement)	Process Implementation	Process Monitoring	
Automation	AS IS	---	**Process Mining** (Kuhn et al., 2019), (Kirchmer & Franz, 2019)	---	**IoT Technology** (Tupa & Steiner, 2019) **RPA** (Kirchmer & Franz, 2019)	**IoT Technology** (Tupa & Steiner, 2019)	TO BE
Digitalization & Integration	AS IS	**Data Mining** (Mehdiyev et al., 2017)	---	**IoT Technology** (Stoiber, 2021) **Computacional/ Artificial Intelligence** (Tupa & Steiner, 2019)	---	---	TO BE
Process Optimization	AS IS	**Process Mining** (Kuhn et al., 2019)	---	**Design Thinking** (Vasilieva & Tochilkina, 2020) **Computacional/ Artificial Intelligence** (Mehdiyev et al., 2017)	**Agile methodology** (Kuhn et al., 2019)	---	TO BE
Process Intelligence	AS IS	---	---	**Process Mining** (Kuhn et al., 2019) **Computacional/ Artificial Intelligence** (Afflerbach et al., 2017)	---	**Process Mining** (Kuhn et al., 2019)	TO BE

Table 3-6 – Summary of the application of technological techniques that resulted from the systematic literature review.

4. FRAMEWORK

4.1. FRAMEWORK'S PROPOSAL FOR THE USE OF BPM IN A DIGITAL INNOVATION PROJECT

Through the information gathered in section 3.3.2, it was possible to organize the main ideas in a table (Table 3-6), which is the starting point to build the framework, thus achieving the goal of the present dissertation. However, despite of the useful information presented in Table 3-6, there are still some gaps that need to be filled (e.g., what to apply in the process discovery phase to automate processes). For this, it is necessary to go back to the comprehensive literature review to find evidence on technologies that fit on the identified gaps - Table 4-1.

The resulting matrix can be considered a facilitator of innovation, by indicating for each type of digital transformation which technology can be applied in what phase of the BPM cycle. Innovation is not a guaranteed result, since there are several variables that contribute to success. Hence, this framework is considered a facilitator for reaching innovation.

Given this, the matrix is composed of rows that represent the transformation categories (automation, digitalization and integration, process optimization, and process intelligence – represented in Table 4-1 by the indexed letters from A to D) and by columns that are the phases of BPM cycle (represented in Table 4-1 by the indexed numbers from 1 to 5, as represented in Figure 4-1). The intersection of the rows and the columns correspond to the specific technology that might lead to an innovative output. To demonstrate this framework's applicability, the following example can be given: Kuhn et al. (2019) and Kirchmer & Franz (2019) have shown how automation can be applied in the process analysis phase by using process mining technology (described in the previous section), contributing with valuable insights for its application in other contexts.

The distinction between the transformation categories identified on the matrix's rows is delicate. Even though some of them might generally be considered each other's subcategories, the four rows were kept to open space for deep exploration of the topics in literature. Process automation has been mostly used in industries like chemical, gas, and power production (Jämsä-Jounela, 2007). It is a helpful technology to increase product quality, improve process safety, and manage resources more efficiently, since by automatizing processes and the activities that compose them, it will not be exposed to human mistakes and will be able to reduce cycle times. The row of digitalization and integration concerns not only the technological aspects, but also the environmental changes that come from technological transformations (resources, physical space, etc). When digitalizing a process, it is also necessary to think about its integration into the existing systems, thus requiring various levels of adaption. Process intelligence is related to the systematic data collection that is afterwards integrated and analysed in order to identify bottlenecks in the business activities and to gain insights related to the operations (Castellanos et al., 2009). Process optimization can be defined as the action of improving a process, by making adjustments that allow users to make the best use of it. Within the scope of process optimization, it would be possible to include the remaining three rows since they all have the goal of optimizing. However, for this category, it was intended to show other techniques that could complement the technological application (e.g., Design Thinking, Agile methodologies).

Digital Transformation Categories	AS IS	Process Discovery (X1)	Process Analysis (X2)	Process Redesign (Improvement) (X3)	Process Implementation (X4)	Process Monitoring (X5)	TO BE
		BPM Cycle Phases					
Automation		**A1**	A2 **- Process Mining** (Conformance checking)	**A3**	A4 **- RPA** (Agile automation) **- IoT Technology** (Cyber Physical Systems)	A5 **- IoT Technology** (Automated real-time monitoring; Digital twins)	
Digitalization & Integration		B1 **- Data Mining** (Data collection)	**B2**	B3 **- IoT Technology** (Connected workflows) **- Computational/ AI** (Intelligent decision networks)	**B4**	**B5**	
Process Optimization		C1 **- Process Mining** (Process modelling from event logs)	**C2**	C3 **- Design Thinking** (Ideation) **- Computational/ AI** (Genetic algorithms)	C4 **- Agile methodology** (Facilitator)	**C5**	
Process Intelligence		**D1**	**D2**	D3 **- Process Mining** (Process enhancement) **- Computational/ AI** (Evolutionary Algorithms)	**D4**	D5 **- Process Mining** (Risks identification in conformance checking)	

Table 4-1 – Numbered slots corresponding to the information gathered in section 3.3.2 and to the identified gaps.

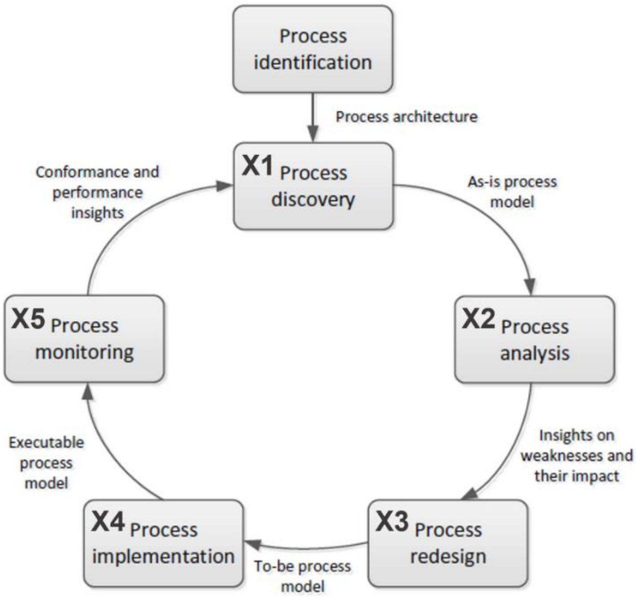

Figure 4-1 - BPM cycle with each phase numbered according to the framework's numeration. X represents the letter associated with the transformation category (framework's rows from A to D).

Below there is the list of the findings, with each matrix section numbered according to Table 4-1. These findings are based on the new research done throughout available literature, in order to fill the gaps not covered by the systematic literature review results.

A1 – Pan Y. & Zhang L. (2021) describe how process mining contributes to innovation by automating process discovery. This approach is applied in the construction industry, where the information collected comes from building information modelling (BIM) event logs, which are then used to model the process. The process modelling is done automatically through inductive mining (Leemans et al., 2013) and fuzzy mining (Günther & van der Aalst, 2007) algorithms, to create a block-structured process with high fidelity, and displaying aggregations of the most significant subsets behaviour, respectively. Given this, the use of process mining together with BIM logs promotes higher efficiency and improved construction quality, thus contributing to innovative solutions in the construction and architecture sector.

A2 – As justified in section 3.3.2.

A3 – Yatskiv et al. (2020) propose a method to automate software testing by using IPA. It consisted of applying a specific interface for object recognition (Computer Vision API), that showed increased flexibility in the interaction between on-screen elements and documents, without the need for hardcode and predefine rules (Yatskiv et al., 2020). The use of this interface added valuable automation characteristics to a simple RPA process, resulting in less human involvement and improved process performance.

A4 – As justified in section 3.3.2.

A5 – As justified in section 3.3.2.

B1 – As justified in section 3.3.2.

B2 – Majeed A. and colleagues (2018) proposed a framework of big data-based analytics to optimize the process of additive manufacturing. This framework consists of several phases, among which is the process analysis that recommends the use of data mining technology to associate, classify and cluster the collected data, although it does not include the algorithm to accomplish it. Nevertheless, this methodology deserves a deeper exploration to guarantee the support of the process redesign phase to take innovation to the next level.

B3 – As justified in section 3.3.2

B4 – Cahyono et al. (2019) showed how to implement workflow automation in the electricity business to improve process performance and deliver higher service quality. This was done by digitizing and integrating a web-based system and a mobile application to automate the work distribution and manage the tasks performed by employees (Cahyono et al., 2019). The result was an increase in employees' engagement and customer satisfaction since the process flow became more transparent and organized within the company.

B5 – Su G. and colleagues (2022) proposed a framework for process monitoring called "*Quantitative Verification for Monitoring*" (QV4M), which was derived based on two recent methods for probabilistic model checking and which monitors Event Streaming Systems (ESS). These ESS are streaming platforms that support the integration of heterogeneous and distributed applications, and which substitute the traditional message queuing middleware. The general functioning of this QV4M is to assume parameters in the probabilistic model as random variables, so then it can infer the significance of the probabilistic model checking output (Su et al., 2022). This technique allows the evaluation of the quality of service by analysing data from centralised streams, thus being able to take conclusions regarding components that produce or consume those same streams.

C1 – As justified in section 3.3.2.

C2 – As described in section C1, Pan Y. & Zhang L. (2021) indicate a methodology for process modelling and its subsequent analysis. The process analysis phase is described using fuzzy mining. Fuzzy mining is applied for frequency and bottleneck identification among the process, thus indicating the sequence of activities with the highest waiting time, dominant rework loops, and contributing to the identification of the delays' main cause (Pan & Zhang, 2021).

Besides technological solutions, one can also recur to ethnographic research (data collection made through direct observation in a natural environment), to apply root-cause analysis techniques. For process analysis some useful creative techniques can be the following: Journey Map creation, to deeply explore all the parts of a process, hence thinking about each step in detail (Doorley et al., 2018); also the 5 Whys is a useful technique to find the root cause of a problem (Jones, 2021). This is done by asking "why" five times, leading to a deeper dissection of the situation after each "why". Hence, this technique uses "counter-measures", rather than "solutions", meaning that it prevents the problem from arising again. The benefits of these ethnographic solutions are that they help in the clarification of the situation and also help in organizing the thoughts, by turning ideas into concrete visualizations.

C3 – As justified in section 3.3.2.

C4 – As justified in section 3.3.2.

To be more specific regarding agile methodologies, examples of techniques that fit in this category to facilitate process implementation would be Extreme Programming (XP) and Lean Six Sigma (LSS). Regarding the first one, XP is a software development methodology, built upon values, principles, and practices. It is executed in small or medium teams and the methodology is leveraged to an extreme, like, for instance, testing the software before it is finished (allows to reveal errors sooner, in smaller pieces of added code), developing code within 10 minutes, or applying pair programming (two people sitting at the same machine) to get a continuous code review. I suggest this methodology, since it enables process implementation by accelerating the development of the activities while turning them more efficient. I also suggest Lean Six Sigma as a way of improving the efficiency of process implementation, due to its capability of waste elimination by applying the Define, Measure, Analyse, Improve, Control (DMAIC) methodology (Gupta et al., 2020). Hence, it is expected that LSS together with big data analytics can result in very good achievements, since LSS can provide this structured measured approach and big data analytics have the tools to predict and analyse the business problems in a more consistent way (Gupta et al., 2020), thus improving process implementation.

C5 – Mustansir A. and colleagues (2022) suggest an NLP-based approach that combines expertise in deep learning and AI. AI is used to automatically collect users' feedback about processes, which is spread across a variety of sources (social networks, media, microblogs, etc). The collected data goes through a pre-processing step to clean the text, and afterwards, that text is classified into different categories (followed by the indication of the suggestion/comment target) through machine learning techniques. This approach firstly contributes to the process monitoring phase, since in the end it returns information about how the process is being perceived by end users. And consequently, it contributes to process redesign in a way that the received suggestions can be applied to improve the process, thus delivering a better user experience.

D1 – Deep learning and AI can also be applied in the process discovery phase, through the NLP approach. Moon J. et al. (2021) presented a deep learning-based pre-training model applied to manufacturing process software applications and monitoring systems. The process started with the collection of event logs, followed by a pre-processing phase to improve the prediction precision. GPT-2, which is a one-way language model, was used because of its good performance in predicting the next event in consideration of the previous that has already progressed. This model allowed to apply NLP in process mining through business process log data, where the process steps were being predicted, thus contributing to the process discovery phase.

D2 – ML/ AI – In the health care sector, it was found that Machine Learning (ML) and AI can also contribute to innovation using BPM. The patient data is continuously being collected, and its journey is designed in a process model. This AS-IS state process is analysed in real-time and the further steps are predicted using ML and AI technology, thus supporting process redesign and implementation according to that information (Szelągowski et al., 2021).

D3 – As justified in section 3.3.2.

D4 – ML/ AI – Following the same approach as mentioned in D2, the process's further steps are immediately ready for implementation, having into consideration the real-time parameters of the patient's condition, through the AI algorithm that communicates its recommendation without the participation of medical personnel. Furthermore, this algorithm also indicates when a doctor's appointment is necessary. All of this makes it possible to reduce the number of hospitalizations, and unnecessary hospital visits, hence contributing to the relief of the health care system and the minimization of the risks associated with hospitalization for a patient with Chronic Obstructive Pulmonary Disease (COPD) (Szelągowski et al., 2021).

D5 – As justified in section 3.3.2.

This framework represents various solutions to be applied in each BPM phase. However, there is a variety of other technological applications and combinations that could be used, which makes this work a recommendation for practitioners across industries. Some other examples that could be considered are the application of AI and ML for process monitoring, being able to detect fraudulent actions and prevent cybersecurity threats (Godbole et al., 2021), or the use of NLP for process discovery and digitalization through email harvesting and classification, to understand the interactions between workflow actors (Abdelakfi et al., 2021).

Given this and based on the information gathered from the comprehensive literature review performed, the framework is completed and presented in Table 4-2.

			BPM Cycle Phases					
			Process Discovery	**Process Analysis**	**Process Redesign (Improvement)**	**Process Implementation**	**Process Monitoring**	
Digital Transformation Categories	**Automation**	**AS IS**	A1 **- Process Mining** (Fuzzy mining and inductive mining)	A2 **- Process Mining** (Conformance checking)	A3 **- Intelligent Process Automation** (Intelligent decision making and interface analysis)	A4 **- RPA** (Agile automation) **- IoT Technology** (Cyber-Physical Systems)	A5 **- IoT Technology** (Automated real-time monitoring; Digital twins)	**TO BE**
	Digitalization & Integration		B1 **- Data Mining** (Data collection)	B2 **- Data Mining** (Classification and clustering)	B3 **- IoT Technology** (Connected workflows) **- Computational/ AI** (Intelligent decision networks)	B4 **- Workflow Automation** (Automatized workflow integration)	B5 **- Event Streaming** (Centralised data streams)	
	Process Optimization		C1 **- Process Mining** (Process modelling from event logs)	C2 **- Process Mining** (Fuzzy mining) **- Root-causes analysis** (Ethnographic research)	C3 **- Design Thinking** (Ideation) **- Computational/ AI** (Genetic algorithms)	C4 **- Agile Methodology** (XP; Lean Six Sigma)	C5 **- Deep Learning/AI** (NLP-based approach)	
	Process Intelligence		D1 **- Deep Learning/AI** (Process prediction - NLP approach)	D2 **- ML/ AI** (AS-IS analysis to predict process's next steps)	D3 **- Process Mining** (Process enhancement) **- Computational/ AI** (Evolutionary Algorithms)	D4 **- ML/ AI** (Implementation of the predicted process's next steps)	D5 **- Process Mining** (Risks identification in conformance checking)	

Table 4-2 - Final framework for digital innovation through the application of the BPM cycle.

4.2. Demonstration – Use Case

In this section, a use case will be presented to demonstrate the application of the proposed framework, regarding process optimization. This will be related to the customer experience in the government services (for renewal of the citizen card, passport, etc.), which in Portugal, can still be a long process, due to the time-consuming waiting lines. This might happen because of several factors, like not enough resources, lack of better technological enablers, and so on.

Given this, a simplified process variant is represented below (Figure 4-2). Furthermore, the demonstration will be conducted according to the process optimization techniques presented in the framework and following the BPM cycle represented in Figure 4-1.

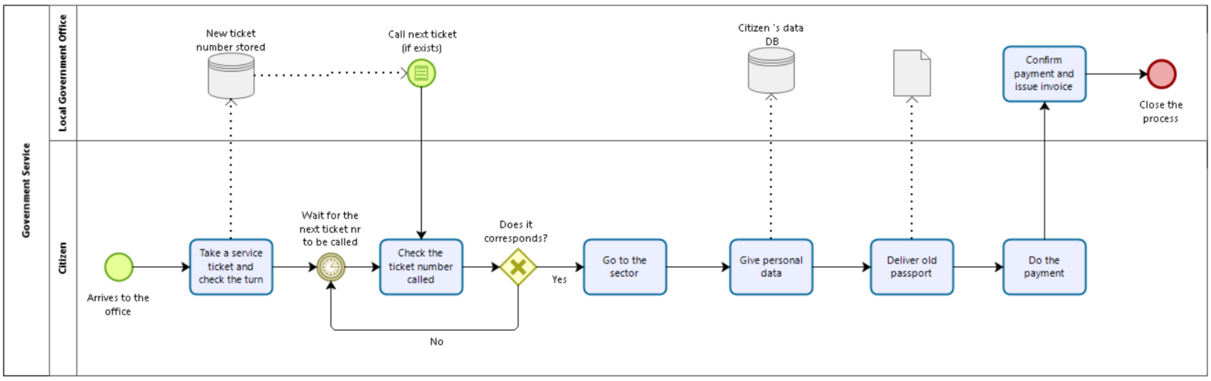

Figure 4-2 - Simplified government service's process variant for passport renewal.

Below there is a description of the proposed techniques to be applied in each BPM phase, which will allow creating innovative solutions while contributing to process optimization.

- **X1: Process discovery** – process mining (process modelling from event logs)

Process mining allows the collection of the interconnected event logs created during the process (e.g., new ticket emission, citizen's file opening, submission of citizen's personal information), thus contributing to designing a model that represents to represent reality. The same process might have different variants, meaning that the activities, or even its sequence of activities could vary, hence not necessarily corresponding to the linear representation example observed in Figure 4-2. Nevertheless, a closer look at these process variants allows a starting point for optimization through the following BPM cycle steps.

- **X2: Process analysis** – fuzzy mining and root-cause analysis using ethnographic research

In this phase, the process variants obtained are analysed to look for bottlenecks and inconsistencies that might be causing delays in the service. Some examples of parameters analysed are the waiting times, the rework performed, the dominant variant, and so on. to optimize this analysis, fuzzy mining and ethnographic research can be used, one complementing the other. With fuzzy mining technology, the goal is to obtain a simplified view of the process, by aggregating and clustering the data. This is done through an algorithm, based on their significance and correlation against a specific process perspective, thus showing an improved visualization, whose focus is on the particular situation that is to be resolved. Ethnographic research can complement this simplified process analysis. For instance:

the fuzzy mining technique returned a model in which it is observed that the activity most time-consuming is “Give personal data”. Ethnographic research can help to understand the root-cause of this situation. The application of the 5 Why’s exercise should be done within a group of people with different backgrounds and experiences, and in a 5-minute brainstorm (it can be iteratively repeated for a total of 25 minutes). It may exist more than one path for the root-cause. One possible path example is the following:

1. “Why is the personal data taking so long to be collected?” – Because it is a manual process.
2. “Why is it a manual process?” – Because some data needs to be updated and inserted into the system.
3. “Why does the data need to be inserted in the system?” – Because there is not an integrated and automatized system to do it.
4. “Why is that?” – Because the current IT infrastructure does not allow it.
5. “Why is that?” – Because it is still the same IT infrastructure from 10 years ago and it has not been updated since then.

It is important to always check each answer, and to work on top of reliable and updated facts. In the given example, one possible root-cause for the service delay is the outdated technological infrastructure used by the government services.

- **X3: Process improvement** – Design Thinking (ideation process application) and AI (genetic algorithms)

After having found a possible root-cause for the service delays, one should think about ways to improve the process. Possible tools are design thinking methodology and genetic algorithms. Regarding design thinking, it comprises a set of steps: empathise, define, ideate, prototype, and test, which involve divergence and convergency actions. For instance, during the empathic phase is it necessary to diverge and try to gain real insights into users and their needs, thus putting aside our assumptions. On the other hand, for the definition phase, a convergence is expected, since it is the time to synthesize the observations on the empathic stage and define the core problems identified (here the 5 Why’s technique can be applied). Currently, and in the process improvement, one is expected to diverge again, to generate ideas. To do this, some other techniques may be applied, like the “How might we” (HMW) questions, brainstorming, or imposing constraints on possible solutions. Taking back to the example of the outdated technological infrastructure, the application of the HMW questions would be as follows:

  - *Challenge*: Improve the IT infrastructure to allow new systems integration.
  - *Point of view*: A person gets frustrated because needs to leave earlier from his job to be 1 hour in the government’s office queue, so then he must repeat all his citizen information (accessed through the citizen card), updating his height, inserting fingerprints, and providing a signature.
  - *How might we* (increase comfort): turn it into a more autonomous process? / do it through a mobile app?

After collecting different HMW questions, only a few are chosen to be taken forward in the process, ending up choosing only one for the prototyping and testing phases.

Regarding genetic algorithms, they are a useful tool to redesign the process through their capacity for error prediction used as input for post-processing step predictions. Hence, there is a continuous improvement in real-time, programmed to obtain the best combinations of activities that lead to a reduction of the waiting time.

- **X4: Process implementation** – Agile methodology (XP, Lean Six Sigma)

When a possible solution is found, one can use the agile methodology to implement it. For instance, taking the previously suggested autonomous process: if the solution is to have a machine that allows to measure the height, take a photo, check digital fingerprints, check the signature and update personal information (address, birth date, marital status, etc), without the need of a government resource, then XP can be used to create the software that answers the specified requirements. This would be done through the typical test-first practice, together with constant feedback and iterative product improvement. The application of LSS methodology allows to organize the work in a careful and structured manner, by applying the define, measure, analyse, improve and control phases. Both XP and LSS help on achieving the implementation goal in a very efficient way, without wasting time on non-value-added activities, contributing to a "ready-to-use" product much faster than a traditional non-agile approach.

- **X5: Process monitoring** – Deep-learning/AI (NLP-based approach)

The demonstration for this step keeps following the example that is being used as a possible solution for reducing the waiting time for the passport renewal process, which is the creation of a self-service machine in the government official representatives. Given this, the NPL-based approach fits the purpose of monitoring the newly redesigned process, since it is an AI solution capable of going through all available sources of feedback/ comments related to the subject, which is something that a human being would take too long to accomplish. Furthermore, it is also capable of organizing the data collected by topics, such as what is a compliment, suggestion, or a claim, depending on the patterns for which it was trained to recognize.

After this phase, it is important to keep the momentum going, through continuous improvement. It is expected to reach an optimized product in each iteration, by being creative, and applying out-of-the-box thinking (to diverge) when and where it is needed.

4.3. Evaluation & Discussion

The evaluation was performed through a focus group, where the problem statement was first introduced, then the framework was briefly explained, and finally, there was space for some questions (Table 4-3) to the invited specialists, to promote discussion between the participants, and to obtain constructive feedback that will be useful for the framework's improvement. The participants were Dr. Pedro Malta **(PM)**, NOVA IMS professor and specialist in BPM, and André Luz (**AL**), Manager at PwC Portugal and specialist in RPA and automation technologies.

Q1	Do you consider the proposed framework useful, and why? If not, why do you believe it is not?
Q2	Do you have any criticism of the proposed framework? Please explain.
Q3	Would you consider implementing the proposed framework? Please clarify why/ why not.
Q4	Do you have any recommendations or suggestions for further improvements to the proposed framework?

Table 4-3 - Validation questions.

Below, is included the transcription of the specialists' answers. This transcription process was performed immediately after the focus group session, to avoid biased information.

<u>First comments on the framework:</u>

PM: Most Portuguese businesses are SMEs, most large companies do not know their processes, and they do not even have them modelled, so we still do not have any starting point. It might make sense to add an initial line, because what we will refer to in the first phase are modelling tools, but there are also modelling tools that already have associated simulators and that allow generating information for mining. It would be interesting to try to support the creation of this framework based on some studies, to support the creation of perspectives of approximation of BPM in business management.

The expression "aligning processes and technology" is not easy, because the alignment of strategies is in itself a process that might also need to be modelled. Luftman has already done a strategy maturity model where he describes 4 ways to align strategies coming from IT or coming from the organisation. This might support your framework.

AL: Is this framework agnostic to the organisation's maturity? And does it work like a cycle? For all processes that have feedback, there is always an initial phase - the first input -, which catalyses all this. For example, in an SME that does not have modelling and it is necessary to do the first initial modelling so that we can then monitor the process, etc, I don't know if it wouldn't be interesting to include a first phase of process design (normalize it, formalize a zero process), so that later we can put the technology on top, log in and apply the various technologies for process mining, identify where are the bottlenecks, where to do the automation, and so on. Because if not, we're going to have to assume that either there is technology that is logging in to the process, or that there is already a process design. If neither exists, it would be difficult to apply the idea. I'm thinking, for example, of an organisation that doesn't have neither an ERP, nor a SAP system to record all the data, so it does not have that base where you can do a process mining. Because most companies are taking market software that is very outdated and they take it from there, and from a set of standard processes, they manage to get an idea of how the activities are interconnected and design the entire "spaghetti" and then we can move on. But if we don't have this, what should our starting point be? I think it might be interesting to identify that at least one of two points already exists: either technology for process mining or that process design already exists.

PM: It could be a pre-phase to your framework. And here the question is in the company's culture: is there already a process mindset? Is process design already part of the management culture?

Answers regarding Q1:

PM: I think it's useful, because of the correlation that exists between the phases and categories for digitization, then identifying the various tools and methodologies to move forward. And even though, it is important to cyclically run the framework, starting from AS IS, getting to the TO BE, and return to the initial point. The only drawback is in the question I posed before, that has to do with the base, whether there is something pre-built, to then apply the framework.

AL: I find it very useful, because it unequivocally identifies the capabilities and technologies that an organisation must have if it wants to implement this culture of process redesign and operational efficiency in its organisation and increasingly improve its processes, including automation and minimization of waste. Also, the IT teams can clearly understand what points of capabilities need to be sought, that is, through team skills, new technology in the organisation and structure, and explain and argue why. So, I find it quite useful, and it also gives us the idea of a playbook that indicates us which tool we need to apply in the stage we are in.

Answers regarding Q2:

AL: Do these technologies have the same level and priority? That is, if in process discovery, does process mining have the same weight as data mining, or deep learning/AI? Which one do you think should be prioritized? My suggestion is that it's easier nowadays for a company to do process mining if it already has a system, than for example deep learning/AI, which is something that is not yet fully mature for most companies. In other words, in terms of weight and quick win and ease of implementation, there may be tools and methodologies that are easier to implement or have a lower cost. And maybe it would be interesting to have some prioritization in this framework or try to link this in some way with the maturity of the company. I think it could bring some added value to this matrix to add a cost axis, or the business case of using some of these technologies, because they don't all have the same granularity, nor do they all have the same weight.

Answers regarding Q3:

PM: Implementing this framework makes perfect sense. It makes sense to look at the base and to that matter of the strategic alignment and of course, to the knowledge that can be made of the company itself: understand what the company is, how it is structured, etc, and then move forward.

AL: Yes, as long as the framework is applied in a cyclical way, I would say yes, and it makes perfect sense to implement it.

Answers regarding Q4:

(Participants made several suggestions and recommendations during the session, so this question was answered in the previous comments presented)

After gathering the feedback of the participants, it was carefully analysed. Therefore, the points of improvement, artefact's utility and general observations made during the focus group session will be discussed on the remaining pages of this section.

Regarding the framework's usefulness, the participants agreed that it was very useful, since it shows the correlation between the different elements in scope, namely, the process management phases, and the digital transformation categories and tools. It was also mentioned that this framework allows an understanding of the capabilities needed in the organisation, and it was compared with a "playbook" for implementation.

However, some points of improvement were identified. This first one concerns the fact of the representation of cyclicity in the framework was not perceptible. It should be clear that it works in successive iterations (from the AS IS state, to the TO BE, and back again to the AS IS for the following iteration).

The second improvement discussed was that it would make sense to include a pre-stage, immediately before the process discovery phase, in order to assess if the organisation either has a well-established process design or it has implemented proper technology that would allow the process mining application. This framework is intended to be transversal to all types of companies, which means adjustments should be made to properly guide the organisation according to its goal. Technology application for itself is not enough if the remaining dimensions are not aligned. This leads to the recommendation topics discussed, namely the business – IT alignment. The participants gave their feedback, not only in terms of academic potential, but also by transposing the applicability of the framework to an enterprise environment, which resulted in interesting insights.

In Portugal, the SMEs' process maturity is still not very developed. Most of the companies in this geography do not have a broad vision regarding their processes, so their modelling capacity seems to be generally poor. Thus, it is important to understand what type of management culture the organisation has, and if there is already a process-oriented mindset. Furthermore, to support the framework, Luftman's model can be referenced. The author presents 4 ways to align the business strategy with the IT strategy. This is of most importance for this study, since the created artefact was not only focused on technology, but also on other digital transformation dimensions (people, organisation, etc). Given this, for the framework's application, it is first necessary to understand the requirements that lead to the value creation and innovation in the following dimensions: *Business Strategy*, *Organisation Infrastructure, and Processes*, *IT Strategy*, *IT Infrastructure and Processes*. Included in each dimension, there are important factors that contribute to the alignment, such as architecture, processes, and skills (example related to "*IT Infrastructure and Processes*"). The evaluation of each dimension autonomously, and its strategic choices and practices, followed by the correlation between the 4 dimensions themselves, results in the maturity level of the organisation. This allows the development of a roadmap with initiatives to create business opportunities – IT alignment and, consequently, motivate the efficient use and application of the framework.

Another important point discussed, was the fact that not all companies have the necessary capabilities and/or budget to apply some of the technologies proposed. The new pre-stages output allows the identification of the requirements for the framework's applicability, consequently facilitating the realization of a cost analysis and technology prioritization according to the budget estimated. The recommendation given by the participants was to include this parameter in the framework as a new axis. It would allow the organisation to understand in which digital transformation category it would be possible to start, considering the available budget and capacities. In each iteration performed, the organisation is expected to be able to evolve to more complex and efficient systems, which might allow the organisation of a roadmap plan.

4.4. Framework's Improvement After Feedback

Some of the feedback received in the focus group session can already be applied to the framework's structure, namely:

i. Clear representation of the cyclicity of the framework (when reaching the TO BE state, it should go back to the AS IS, through successive iterations), since the way how it is currently being represented is not that transparent (Table 4-2).

ii. Before entering the process discovery phase, an initial stage should be considered, to analyse what is the current state of the organisation in terms of the 4 Luftman's dimensions. This aims to create the optimal conditions to apply process mining and discovery techniques. Hence, this assessment should first include the evaluation of the current business–IT alignment, as discussed in the previous section. Besides evaluating the business-related factors, it also includes the evaluation of the current systems' existence and/or availability (ERP and other "business essentials" like CRM, for instance), to guarantee that there is a base, and it is possible to work on top of that. Process mining technology, particularly, can only work if it has the necessary connections to the systems that continuously store and send the data as event logs. The implementation of these systems should be analysed by IT teams, together with the business and governance structures, so the entire organisation is aligned and aware of this transformation's purpose. Despite of these ideas and discussions, the immediate improvement made was in the framework's structure. The development of the strategy for the maturity assessment will be here referred to as future work.

Given this, the final version of the framework is represented in Table 4-4. The remaining points discussed in the previous section will also be allocated in section 5.3, for future work.

(i.)

BPM Cycle Phases

Digital Transformation Categories

(ii.) Evaluation of business – IT alignment, roadmap design and application

AS IS → TO BE

Digital Transformation Categories	Process Discovery	Process Analysis	Process Redesign (Improvement)	Process Implementation	Process Monitoring
Automation	A1 **- Process Mining** (Fuzzy mining and inductive mining)	A2 **- Process Mining** (Conformance checking)	A3 **- Intelligent Process Automation** (Intelligent decision making and interface analysis)	A4 **- RPA** (Agile automation) **- IoT Technology** (Cyber Physical Systems)	A5 **- IoT Technology** (Automated real-time monitoring; Digital twins)
Digitalization & Integration	B1 **- Data Mining** (Data collection)	B2 **- Data Mining** (Classification and clustering)	B3 **- IoT Technology** (Connected workflows) **- Computational/ AI** (Intelligent decision networks)	B4 **- Workflow Automation** (Automatized workflow integration)	B5 **- Event Streaming** (Centralised data streams)
Process Optimization	C1 **- Process Mining** (Process modelling from event logs)	C2 **- Process Mining** (Fuzzy mining) **- Root-causes analysis** (Ethnographic research)	C3 **- Design Thinking** (Ideation) **- Computational/ AI** (Genetic algorithms)	C4 **- Agile Methodology** (XP; Lean Six Sigma)	C5 **- Deep Learning/AI** (NLP-based approach)
Process Intelligence	D1 **- Deep Learning/AI** (Process prediction - NLP approach)	D2 **- ML/ AI** (AS-IS analysis to predict process's next steps)	D3 **- Process Mining** (Process enhancement) **- Computational/ AI** (Evolutionary Algorithms)	D4 **- ML/ AI** (Implementation of the predicted process's next steps)	D5 **- Process Mining** (Risks identification in conformance checking)

Table 4-4 – Improved framework – adjustments done according to the feedback received in the focus group session.

5. CONCLUSIONS

This chapter concludes the work of this dissertation, by presenting the main conclusions, limitations, and future work. It also delivers the understanding of whether the goals proposed for this work were achieved and if the research question identified was successfully answered.

Considering the collected feedback obtained during the focus group session in the evaluation phase, one can acknowledge that the proposed objectives were fulfilled, and the developed artefact can give answers regarding how BPM contributes to innovation, using not only technology, but also creative enablers, flexibly and continuously, through an organized and oriented set of phases (BPM cycle).

5.1. SYNTHESIS OF THE DEVELOPED WORK

This work's inception was a literature gap, which originated a research question that, in turn, guided the conducted research. The investigation's scope included a variety of concepts within the fields of BPM, digital innovation, and digital transformation. Furthermore, technological tools and efficiency methodologies were also studied separately, and the relationship between them all was also considered.

This project aims to assess the role of BPM in digital innovation projects, and it was done by building a framework that guides organisations through different implementation plans, by incorporating BPM, technology, and innovative methodologies. Finally, the framework was validated by specialists in the fields of BPM and automation, which resulted in an updated version of the artefact and new interesting insights for further work.

5.2. LIMITATIONS

The first limitation worth mentioning is related to the framework's evaluation. Even though it was approved by specialists of different fields, it would have been more insightful if the number of participants was higher, to hear perspectives from other study fields.

Furthermore, another improvement would be to further enhance the literature search to make it more extensive and complete. Particularly, for the systematic literature review, a deeper experimentation and analysis of other strings combination might have resulted in more relevant articles from different fields of study. Hence, the framework's construction was limited to the information gathered in this stage, which might not be representative of the complete available scope.

The implementation cost can also be considered a limitation of this framework, since it involves different techniques and technologies that, to be implemented, require a very mature organizational environment.

Finally, one should also mention the limitation related to technological evolution. The created framework is composed of a variety of technologies and methodologies. However, technology is constantly changing, and what is being now pointed to as an innovation, in the future may become obsolete. So, the lifespan of the presented artefact is also limited in time and should be updated according to technology improvements/evolutions.

5.3. Future Work

There is still a lot of work to be done in this research field. BPM's role is not yet being seen as a fundamental enabler of innovation within the enterprise environment.

From the work performed in the present dissertation, one can define some possible research paths: first, design the maturity assessment strategy, so it can be used as a pre-stage in the framework for the alignment of business and IT. Second, to conduct and represent a prioritization of the technologies included in the framework, according to the necessary budget for implementation and the organisation's maturity. It is important to consider and include a cost axis, to help guide organisations during the definition of their strategy.

Furthermore, the framework should be continuously expanded, with the inclusion of the most recent technologies and process trends. To do that, it might be useful to expand the research scope to other scientific databases, thus conducting a more complete investigation.

Regarding the evaluation stage, it should be done with the participation of more specialists, from different areas, not necessarily technological, namely Design Thinking and Agile Methodologies. This allows a more insightful experience.

Finally, the testing of the framework's applicability in a real enterprise environment would be an enriching experience. That would be a good opportunity to identify gaps and opportunities for improvement, consolidate the concepts and understand the real interaction between the methodologies and the BPM cycle phases.

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ANNEX

Focus Group's Transcription (PT)

The focus group's transcription regarding the proposed framework's evaluation phase of the present dissertation is represented in this section. In order to respect the original statements of the participants, the transcript text preserved the original language.

Date: Friday, 24th June 2022

Location: Online Meeting

Participants short presentation:

1. **André Luz (AL)**

André has graduated from Electronics and Computer's Engineering by Instituto Superior Técnico. His career started at PwC, as an IT Consultant in Financial Services, then moving to Bearing Point for 4 years and a half, until going back to PwC in 2021, as Manager in Technology Strategy & Architecture. His professional path was always linked to information systems and technology projects.

2. **Pedro Malta (PM)**

Prof. Dr. Pedro Malta has graduated from Decisional Systems Engineering by Instituto Superior de Informática e Gestão, completed his masters' degree in Economics by Instituto Superior de Gestão, and completed his information systems' postgraduate studies by Universidade do Minho. He has worked has a professor in COCITE, Universidade Lusófona de Humanidades e Tecnologias and NOVA IMS, where he currently teaches. Prof. Dr. Pedro Malta is also the founder and executive manager of Mental Kids, since 2017.

Initial comments, after the framework's explanation

PM: A maioria do tecido empresarial português são PMEs, a maioria das grandes empresas não conhecem os seus processos, não os têm nem modelados, por isso não temos ainda nada modelado para servir de ponto de partida. Não sei se faz sentido ser uma linha inicial, porque o que se vai referir numa primeira fase são ferramentas de modelação, mas também há ferramentas de modelação que já têm simuladores associados e que permitem gerar informação para o *mining*.

Seria interessante tentar sustentar um bocadinho a criação desta *framework* com base em algum estudo, para sustentar a criação de perspetivas de aproximação do BPM na gestão de empresas.

A expressão que aqui tem escrita: "*alinhar processos e tecnologia*" não é fácil, porque o alinhamento de estratégias é em si um processo que poderá eventualmente estar já modelado. Se for ao modelo de alinhamento estratégico, já tem um estudo de maturidade feito pelo senhor Luftman, e ele descreve 4 formas de alinhar as estratégias vindos do IT ou vindos da organização. Até temos aqui sustentação se calhar para a sua *framework*.

AL: Esta *framework* é agnóstica à maturidade da organização?

Author: Correto, era suposto ser transversal, sim.

AL: É suposto ser uma *framework* que demonstra alguma ciclicidade?

Author: Correto.

AL: Para todos os processos que têm *feedback* há sempre uma fase inicial que é primeiro *input*, serve como catalisador de tudo isto. Por exemplo, numa PME que não tem modelação e é necessário fazer a primeira modelação inicial para depois conseguirmos monitorizar o processo, etc. Não sei se não seria interessante incluir uma primeira fase de desenho do processo (o normalizar, formalizar um processo zero), para depois conseguirmos incorporar a tecnologia em cima, fazer o *login* do mesmo e aplicar as várias tecnologias para o *process mining*, identificar onde estão os *bottlenecks*, onde fazer a automação, e por aí fora. Por que se não, vamos ter de assumir que, ou já existe tecnologia que está a fazer o *login* do processo, ou que já existe um desenho do processo. Se não existir nenhuma das duas…

Estou a pensar por exemplo, numa organização que não tem nenhum ERP, ou não tem, por exemplo, um SAP que está a registar todos os dados e não tem essa base onde se possa fazer um *process mining*. Porque a maior parte das empresas estão a pegar em *softwares* de mercado que estão muito desatualizados e eles pegam por aí. E a partir de um conjunto de processos *standard*, eles conseguem ficar com ideia de como é que as atividades estão interligadas e desenhar todo o "esparguete" para depois conseguirmos passar do novelo. Mas se não tivermos isto, qual deverá ser o nosso ponto de partida? Acho que poderá ser interessante, ou pelo menos identificar de alguma forma que é como um pressuposto que já existe um dos dois pontos: ou tecnologia para o *process mining* ou que já existe desenho de processos.

PM: Poderá ser uma pré-fase à tua *framework*. E aqui a questão está na cultura da empresa: já há um *mindset* de processo? Já faz parte da cultura da gestão o desenho do processo?

Q1: Considera que a *framework* proposta é útil; e porquê? Em caso negativo, pode justificar, por favor?

PM: Eu acho que é útil, pela correlação que existe entre as fases e as categorias para a digitalização, identificando depois as várias ferramentas e metodologias para se avançar. E ainda que é importante fazer ciclicamente a *framework*, partir do *AS IS* e voltar ao *TO BE*. Mas acho que é muito útil, sim. O único senão está na questão que pus que tem a ver com a base, se existe ou não existe alguma coisa, para depois se aplicar a *framework*.

AL: Eu acho bastante útil, porque identifica de forma inequívoca quais são as capacidades e tecnologias que uma organização deverá ter se quiser implementar na sua organização esta cultura de redesenho de processos e eficiência operacional e melhorar cada vez mais os seus processos até de automação e minimização de *waste*. Por isso acho que sim. Nós daqui conseguimos retirar, e as equipas de IT conseguem perceber claramente quais os pontos de capacidades que é necessário ir buscar, ou seja, através de *skills* de equipa, de nova tecnologia na organização, e estruturar e explicar e argumentar o porquê. Por isso acho bastante útil, e dá-nos também a ideia de quase um *playbook* de, para a fase em que estamos, qual é a ferramenta que precisamos de aplicar.

Q2: Tem alguma crítica a fazer relativamente à *framework* apresentada? Por favor, explique

AL: As tecnologias têm todas o mesmo nível e prioridade? Ou seja, se no *process discovery*, o *process mining* tem o mesmo peso que o *data mining*, ou que o *deep learning/AI*? Qual é que achas que deve ser priorizado, está por ordem na *framework* já?

Author: Não há propriamente uma ordem aqui porque ia depender das categorias de transformação digital que fossem aplicadas ou que correspondessem à realidade de uma determinada organização. Portanto o seguir a linha da automação ou a linha da digitalização, dependeria do objetivo da estratégia da organização.

AL: Aqui é minha sugestão é que é mais fácil hoje em dia para uma empresa fazer *process mining* se já tiver um sistema, do que por exemplo *deep learning/AI*, que é uma coisa que ainda não está totalmente madura para grande parte das empresas. Ou seja, a nível de peso e de *quick win* e facilidade de implementação, pode haver aqui ferramentas e metodologias que são mais fáceis de implementar ou que têm um menor custo. E se calhar seria interessante ter nesta *framework* alguma priorização, ou tentar ligar isto de alguma forma com a maturidade da empresa. Acho que poderia trazer-se alguma mais-valia para esta matriz dar se calhar esse eixo do custo, ou do *business case* da utilização de algumas destas tecnologias, porque não têm todas a mesma granularidade, nem têm todas o mesmo peso.

Q3: Consideraria implementar a *framework* proposta? Por favor, explique por que o faria/ não faria.

PM: Implementar faz todo o sentido. Faz sentido olhar para a base e para a questão do alinhamento e claro ao conhecimento que se pode fazer da própria empresa: perceber que empresa é, como está estruturada, etc, para depois avançar.

AL: Sim, a partir do momento em que se aplica a *framework* de forma cíclica, eu diria que sim, e faz todo o sentido.

Q4: Tem alguma recomendação ou sugestão de melhorias futuras à *framework* apresentada?

(os participantes foram dando várias sugestões e recomendações durante a sessão, pelo que esta pergunta ficou respondida em comentários anteriores)