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How to accelerate digital transformation in companies with Lean Philosophy? Contributions based on a practical case

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ABSTRACT

The market is constantly changing, requiring adaptation by companies to remain competitive. Many companies have already tried to achieve this goal by using the Lean Philosophy, and now aim to adopt Industry 4.0 practices, such as digitalization. However, there are several studies that report difficulties in adopting these practices, requiring for their success a dedicated and well-defined strategy. The present project arises in this context and aims to propose mechanisms to initiate/accelerate the digital transformation of companies in Lean industrial environments. As results, besides the framework to support the journey in this domain – a roadmap based on Lean and BPM – a technological tool to help companies throughout the digital transformation was also developed and proposed. Thus, theoretically this study contributes to increase knowledge in an emerging area, while guiding business managers in adopting the new digital paradigm from a practical perspective.

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1. Introduction

1.1 Background

New challenges related to increased competitiveness and competition, the constant demand for flexibility, increased market volatility, and the demand for shorter delivery times, are emerging every day in manufacturing companies. All of which means that company performance has to increase significantly [1]. In this way, it is necessary for companies to adapt, looking for new opportunities to reach their goal, to achieve competitive advantage in the turbulent market, and to ensure the sustainability of management practices such as Lean Manufacturing and Industry 4.0 (I4.0) [2].

Advances in technology resulting from the fourth industrial revolution have heightened the need for digitalization in companies, forcing them to move from a traditional environment to a digital one. Industry 4.0 is a concept that comes from the fourth industrial revolution, and the Cyber-Physical Systems (CPS), is a key concept of I4.0, allowing the interconnection between the virtual world and the physical world, thus contributing to increased flexibility and adaptability of production systems [3] [4].

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Therefore, in this journey of introducing Industry 4.0 technologies, it is needed to preserve the practices already implemented in the company, such as the Lean Philosophy [5]. In Industry 4.0 the technologies can be aligned with the strategy of knowledge management in organizations, which through data extract information and in turn knowledge, creating value, improving the decision-making process, and in this way promoting the efficiency of operational systems, support innovation, and consequently increasing the competitive advantage [6].

Lean manufacturing is a concept that aims to eliminate waste, to increase productivity and quality, producing "greater quantity in less time, with fewer resources and reduced inventories and capital" [2], [7], [8]. This is known for its ease of implementation and success in achieving the objectives previously established [2].

According to Sony [9], lean manufacturing approach is an enabler to the implementation and integration of Industry 4.0 technologies in the manufacturing environment. Lean is a concept used to increase process efficiency by eliminating activities that do not add value (waste), producing "greater quantity in less time, with fewer resources and reduced inventories and capital" [2], [7], [10]. Taking into account that the introduction of Industry 4.0 technologies culminates in the digitalization of processes, if these are inefficient, consequently, their automation will only contribute to a decrease in their efficiency, thus decreasing the overall company's efficiency [11], [12]. This challenge highlights the importance of working on process management as the basis for a digitalization process. Regarding this matter Business Process Management (BPM) is a methodology for managing business processes, through their mapping, analysis and control, that allows the company to increase the efficiency and effectiveness of business processes [13], [14]. So, to introduce the concept of Industry 4.0 in companies, it shows relevant that processes are mapped and controlled. In fact BPM is understood by some authors, as a tool that supports and benefits the digital transformation [11], [15].

Digital transformation is not only characterized by the adoption of new technologies, but also by the development of a strategy that allows for their successful implementation, which can be considered a challenge in this journey towards the integration of Industry 4.0 [16]–[18].

Furthermore, Ghobakhloo [19] states that Industry 4.0 requires a comprehensive strategic roadmap that visualizes every step forward on the path to a fully digital manufacturing enterprise. This roadmap should assess and analyze the initial state, set specific goals aligned with the company's strategy, and provide an action plan to move to a successful level of digital maturity [20].

Thus, it can be concluded that it is essential that companies develop a strategy, having a procedure that allows them to initiate and/or foster, what is their digital maturity, in order to be successful. However, by analyzing the literature, it is possible to see that there is a lack of methods and procedures that supports the organization in this journey [21]. "The way that Industry 4.0 technologies are integrated into existing production systems and which processes they can support is still under investigation" [22].

It is precisely this gap that is at the root of the motivation to develop this study, that aims to create a procedure (tool) that supports companies with lean mindset, in this digitalization journey, answering the question: (Q1) *"How can companies initiate and/or accelerate the digital transformation?"*. This development took into consideration a pressing need reported in the literature, but also practical experience in the context of a construction industry company where the pilot study was carried out. Thus, the main propose of this study is to contribute with mechanisms to initiate and/or to accelerate the digital transformation in any companies that already have lean practices in their management culture.

1.2 Aims and Methods

To get to the final goal stated above, two steps were defined, translated into two more specific questions. First it was necessary to answer the question: (Q1.1) "How should the transition from a traditional organization to a digital organization be executed?". From this question emerged the need for and importance of developing and implementing a digitalization strategy to organize this transition, a roadmap for digital transformation.

After developing this roadmap, it was understood that it would be important to make this digitalization process faster and more agile, and the second specific question emerges: (Q1.2) "What can be done to accelerate the digital transformation?". Having in mind that the digitalization path must be done in phases, emerge the need to find something that collects and selects the most beneficial/priority processes to be digitalized according to the long-term goals of the organization, enabling the development of a thoughtful and structured action plan, thus supporting the roadmap for digital transformation.

In order to find a solution, an intense literature review was performed, where it was clear that there is a lack of technological tools that support this digital transformation process, so it was necessary to create it. This tool developed in the form of a web application, through the Microsoft Power Platform, which was named DiYD (Do it Yourself Digitalization). This tool intends to understand which processes priorities are to be digitalized in order to achieve long-term business, by inserting new opportunities to be digitalized and their ranking, in order to simplify the selection process, transmitting information necessary for an action plan to be drawn up, and thus proceed with the digital transformation, in a faster and more precisely way. The tool was designed following an agile development, allowing an iterative and incremental approach, since while users evaluate the tool and put additional requirements on it, these are being implemented. After the completion of three iterations, the final model of the application was arrived at, to which usability tests were applied to understand the opinion of the future users about the tool. Finally, the last adjustments were made, based on the comments filled in during the tests, thus arriving at the final version of the application.

As already mentioned, this study was conducted in a construction industry company present in more than 60 countries, characterized by management practices based on the Lean philosophy.

The Figure 1 summarize the methodology that was used in the execution of this study and development of the application.

In order to achieve the objective stated before, the document is organized as follows: Section 2 focuses on presenting a theoretical background of the concepts that will be approached in the practical case, explaining concepts such as Lean Information Management, Lean 4.0, Business Process Management (BPM), Business Process Model and Notation (BPMN), challenges of digitalization. Section 3 describes the practical study from a construction's company in which these concepts are incorporated, according to the methodology explained before. Last, but not least, section 4 presents the discussion and the conclusion, as well as the limitations and the future work to be implemented to overcome this same limitation.

2. Theoretical Background

2.1 Digitalization and Lean Information Management

As it is known, Industry 4.0 can drive the digitalization of company value chain processes [23], which can be productive or even administrative [24]. In the case of productive processes, lean management is one of the methodologies adopted to achieve improvements. In the administrative processes, which evolves information flows, the philosophy most used is the Lean Information Management (LIM) [24], that combine two well-known concepts, i.e., the Lean philosophy and Information Management [25]. While the Lean is a philosophy that "bringing value to customers by reducing inefficiencies" [26, p. 4], the Information Management is a practice that adding value to information due to the way it is "organized, visualized and represented" [24, p. 1]. The main objective of LIM is to solve waste problems, focusing on the value of information and knowledge [27] and also on the control of information processes, promoting better information management to the company [27].

Bevilacqua (2015) cites the principles of LIM advocated by Womack, and the first of which is to "Simplify every process to minimize the need for information management". This principle is aligned with the need to work at process management level and also with lean practices to eliminate waste [28]. The waste associated with information can be presented in different forms, such as: additional actions and inactivity resulting from the lack of updated and appropriate information Hicks as cited in [25].

In this way, processes need to be mapped and analyzed to understand their current state, and thus waste in the information flow is identified [27]. The digitalization process happens in a similar way, processes are rethought and adapted to the digital con-

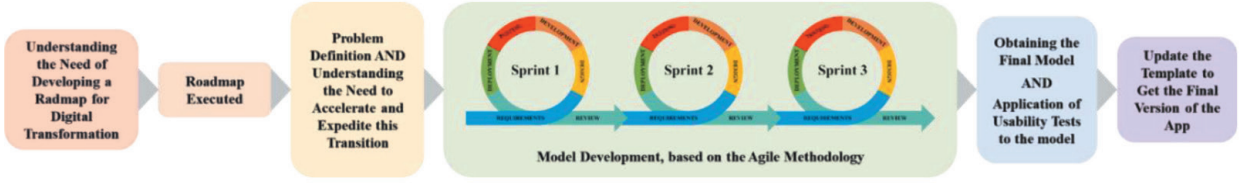

Figure 1. Steps to obtain the final tool

text [29], and in this transition it is expected to follow the principles of LIM and that the process of obtaining, representing, and so on. becomes more agile.

This Digitalization generates a huge amount of data, usually not structured and organized and not available in real time [25]. This way, most of this amount of data is not user-accessible as tools and technologies are needed to support the collection, transformation, analysis and visualization of the data, in order to make it meaningful when making decisions, as it is a complex process for those that are traditional techniques and software [30], [31]

Big data, being one of the cyber-physical systems of industry 4.0, is one of those technologies that describe the massive amount of data [30], [32]. This phenomenon of handling heterogeneous data from different sources is called data integration, and there are several approaches to do this [30]. Bansal [30] also describes Extract-Transform-Load (ETL) as a process used for data integration, proposing an ETL framework to rich the truly significant of data.

The technology comes from Industry 4.0, can be used in different ways and can benefit from the application of the lean philosophy to information processes, as stated before. This is because it is easier to see what information is really needed, thus eliminating waste in terms of data and its processing [25].

2.2 Digitalization and Process Management

Nowadays companies have been forced to seek competitive advantage in the markets, and Business Process Management (BPM) has been adopted in order to reach this goal [33]. BPM, as the name implies, represents the management of a company's processes with the aim of improving its agility and performance [34], [35]. However, BPM is not about creating diagrams [34], and for that the concept of Business Process Model and Notation (BPMN) appeared. BPMN is the standard language used to model and map business processes, which has been an alternative language to be used by everyone (both in industries and academia), for its simplicity and intuitiveness [33].

According to Koszela [36], modelling should be done in two distinct phases: firstly, the process is represented as it is today, through the development of the AS-IS model; in a second phase, the desired future state of the process is elaborated, using the TO-BE model. In this transition the business objectives should be considered (e.g., decrease in cost, increase in productivity, etc.).

Antonucci et al. [15] concluded that BPM, in a general, can have positive implications on the path to digital transformation, mitigating some challenges, such as the fear of the unknown and the so-called resistance to change. For example, the management and modelling of processes, through the identification of processes to be improved, discovering the current state of processes and through indicators associated with the process propose the necessary changes to develop the future state, can help address the challenge identified above.

2.3 The Challenges of Digitalization in the Current Context

Digitalization is no longer a "future trend" and has become a necessity for companies that want to survive in the market [37]. However, this need brings enormous challenges for companies for a variety of reasons, among which:

- difficult to analyze the cost-benefit of the investment, due to the inability to estimate the value it would bring to the organization, as it causes a change in several areas [16], [37], [38];
- need for the intervention of all employees [39], as well as their qualification and acceptance for change [40];
- it is a time-consuming transformation [12];
- the common data cybersecurity issues [19], [41];
- requires skills at the human resource level [19];
- difficulty in managing the large volume of data that is generated and its heterogeneity, being necessary to analyze them to convert them into useful information through a unified view of data [42], since these data cannot be used directly [43];
- high investment need in new technologies [38], [44] and to adapt the organization to be capable to adopt Industry 4.0 paradigm [39], [45];
- the need for implementation to be designed (customized) for each organization [40].

To address these barriers, it is important to develop an Industry 4.0 roadmap to guide this digital transformation, and it should be noted that there is no standard protocol for this implementation [16], [19], [37]. According to Westerman et al, many companies have been realizing that before starting to change to the digital paradigm, it is necessary to define a starting point, developing a roadmap [46], taking advantage of the methodologies already implemented in the organization, such as the lean philosophy (that

is needed to be successful in this path), while still being able to mature these practices [12], [47].

Some authors also highlight recommendations to consider when the moment of develop the roadmaps for digital transformation [48], [49], such as: "Define an action guiding strategy"; "Align objectives with a long-term strategy"; Formalize and "Document the relationship between strategy and individual objectives"; "Observe new market trends"; etc. Some author also stresses the need to "develop and implement an appropriate action plans" when a need (or problem) for digital transformation arises: [48]. To solve this, the current state and the target state must be defined and evaluated, and actions must be identified, prioritized, and implemented. Moreover, according to Bastos et al. [50] the human factor is considered fundamental to digital transformation, to the extent that they should be "at the center of this innovation", since they are affected by it.

3. Practical Case

This section is divided according to the two steps defined above in the section 1.2.. On the one hand, the first section (3.1) will describe the roadmap for digital transformation, answering the first question stated above (Q1.1). On the other hand, the second section (3.2) will describe a technological tool, in order to answer the second question presented above (Q1.2).

3.1 Roadmap for digital transformation

The research began by highlighting those that are the challenges of Industry 4.0, based on the literature, emerging 3 assumptions that were considered in this research: (1) Lean maturity must already be pre-established on the shop floor, i.e., for Industry 4.0 technologies to be successfully implemented, it is essential that value be added beforehand by eliminating all waste; (2) the company's processes must be mapped and standardized in advance, so that gaps and opportunities for improvement are more easily understood; (3) the need for an action plan to facilitate the digital transition, according to the company's long-term strategy, in order to establish priorities.

There are interesting contributions of techniques and solutions that enhance the improvement of the digital transition, but there is a lack of something that interconnects the concepts, BPM, lean philosophy and Industry 4.0 technologies. In this manner, this work intends to interconnect these concepts, to enable the success of this journey of transition from a company that operates in a traditional way to the digital one, overcoming this way the challenges stated above.

Therefore, for the digitalization of the company's processes, a methodology was proposed based on management methodologies, Lean, PDCA and SDCA, and process methodologies, BPM and BPMN, constituting the roadmap for the digital transformation.

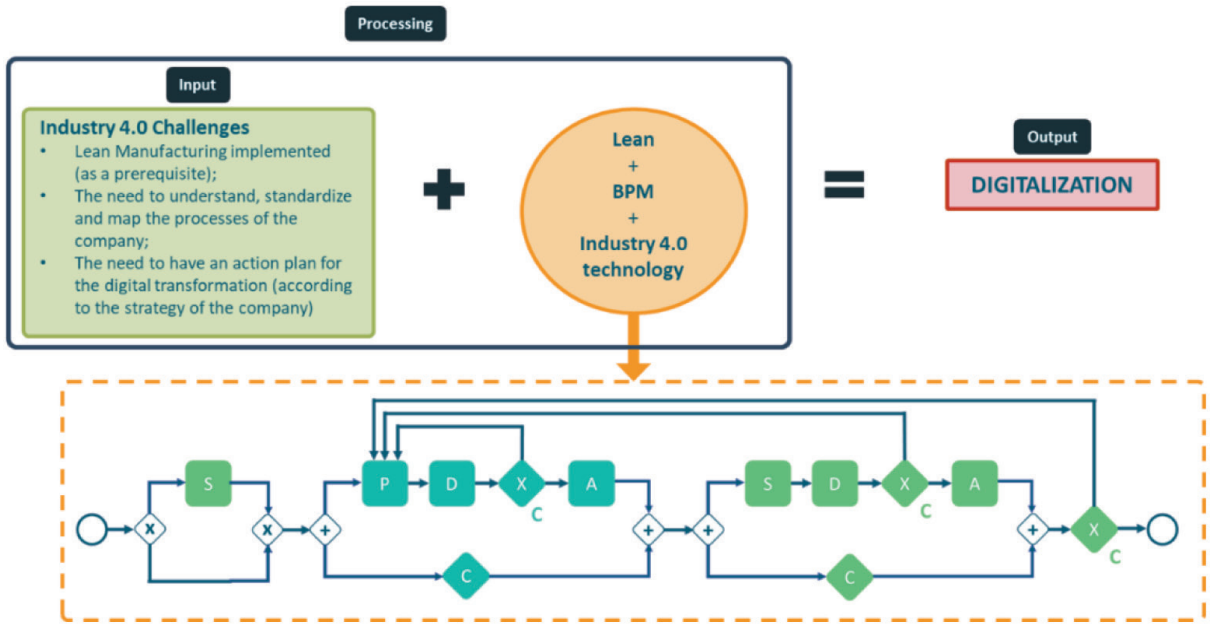

Figure 2. Framework for the digital transformation

This presents a strategy to create a guide that supports companies in this transformation journey, where the roadmap is inserted, that can be spread to other companies, of the same context as the one used in the study, or not.

Very briefly the roadmap starts with the standardization of the company's processes, if they are not already standardized. In case they are already standardized, a PDCA is automatically performed. This begins with planning, in order to understand which of them are priorities to digitize (according to some indicators), then these are digitized, evaluated and adjusted, and are continuously evaluated to understand if what is being done meets the proposed objectives. If not, it is necessary to go back to the planning phase. Then an SDCA is performed, starting with the standardization of the process with the implemented improvements, where 2 situations can occur: (1) if the standard is not being followed and if it is only necessary to perform minor adjustments, one moves to the "do" phase, the process continues to run according to this standard, being continuously evaluated and adjusted. ; (2) on the other hand, if major adjustments are needed, or if improvement opportunities are found, you move to PDCA again.

To support this methodology, a tool was developed to make this roadmap more agile and faster. This technological tool supports the Plan (P) phase of the roadmap, since this is a crucial phase, where the development of an action plan is inserted. This tool allows the evaluation of the processes (opportunities to be digitized), according to an index (ICE - Impact, Cost and Ease) parameterized by the company, in order to prioritize those that will have more impact on the long-term strategy of the company, considering the available capex (capital expenditure), resources and time.

3.2 Description of the tool

From the analysis and application of this roadmap, the need emerged to make it more agile and faster. Thus, it became crucial to answer the question: "What can be done to accelerate the digital transformation?". It was understood that by using a technological tool, it would be possible to meet this need. This section demonstrates that tool, which is inserted in the planning phase of the roadmap for digital transformation, since this is a crucial and complex phase. First, the requirements were defined, together with the users, in order to conclude how the information would be processed in the tool.

Analyzing the users' requirements through meetings, it was possible to reach the following conclusions: need to insert opportunities to scan, introducing all the characteristics of the same in order to calculate the ICE index value automatically; possibility to consult, edit and delete those same processes; need to specify those same opportunities, adding the corresponding tasks; possibility of modeling through the update of the BPMN models of the initial and final status of the process, taking into account the improvements found; alternative of downloading a pdf file for each process with some characteristics of the same in order to make its evaluation easier; possibility of parameterizing the ICE index; need for a dashboard for the analysis and evaluation of the priority processes going forward according to some KPI's; need for save all data in SharePoint.

Next, these were analyzed, and the architecture of the tool was developed, showing how the elements correlate inside the system (Figure 3).

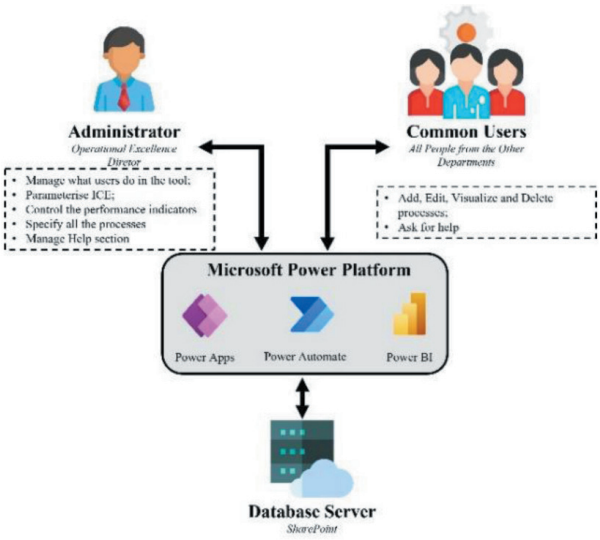

Figure 3. Architecture of the tool

The tool in the form of an app can be used by 2 different types of users, namely: (1) by the staff of all departments (ordinary users), who can insert opportunities to be scanned, edit, view, and delete them, and also consult the user guide (which shows how the app can be used), and if any questions persist a message can be sent by email directly to the administrator; (2) the director of the operational excellence department (administrator), who has total freedom within the tool, being able to perform all the tasks previously mentioned, and also to parameterize the ICE index, analyze and evaluate the indicators from the dashboard obtained by power BI, allowing the control of the digitalization project, manage the help requests from common users, and also to refine each of the inserted processes.

Figure 4. Screens of the tool ("Initial Menu"; "Add Process"; "Processes", respectively)

Figure 5. Screens of the tool (Specification Module; Modelling Module; File Module, respectively)

Then, the tool was developed following an agile development, using the Microsoft Power Platform. The Microsoft Power Platform, being one of the software's that can be used in this field, allows you to work with data, featuring a simple and intuitive interface so that it is easily used by the user. This platform is composed by four different applications: Power Apps; Power Automate; Power BI and Virtual Agents. [51], [52].

To create this technological tool, the following were used: Power Apps (in the development of the tool, allowing interaction between the system and the user), Power Automate (allows the execution of automatic flows) and Power BI (enables the analysis of data that can be measured in the application). Also, SharePoint was used as the database.

Below the screens of the tool will be demonstrated, which took into account the comments stated during the test's phase, as well as a brief explanation of how it works.

As can be seen in Figure 4, the application starts with the initial menu where it is possible to choose the module to visit: "Add Process"; "Processes"; "ICE Index"; "Performance Indicators"; and "Help". The "Add Process" screen allows the user to add a process or scan opportunity, filling in all its characteristics, obtaining the ICE index value automatically calculated from the parameters filled in. The system's "Processes" module allows the user to consult the processes that have been inserted, searching by name, and is the screen that allows access to the functions of editing, viewing, deleting, specifying, and modeling.

The Figure 5 shows the modules for specifying and modelling processes, and also the module for developing a pdf. In the first one the user can add, delete or edit the tasks corresponding to the selected process. In the second, BPMN files of the current state and future state of the process can be attached, and Lean Information Management is used to evaluate the actual state in order to eliminate wasteful tasks. The third allows the download of a pdf containing some of the process characteristics that will be stored in SharePoint due to the flow created in power automate.

Figure 6. Screens of the tool (ICE Index Module; Performance Indicator Dashboard; Help Module)

The figure above, Figure 6, represents, respectively, the ICE index module, the dashboard in Power BI, and also the help module. The ICE index module allows the parameterization of this index according to the objectives set by the company, in order to evaluate the most beneficial processes to digitalize, according to the desired goal. The dashboard allows you to analyze and evaluate key performance indicators (KPIs) in order to monitor the digital transformation project. Last but not least, you can ask for help, either by consulting the user guide (pdf that can be downloaded directly from the app), or by sending an email message to the tool administrator.

After achieving the final stage of the tool, the usability tests were applied individually, in order to evaluate the level of receptivity of the application by all type of users, the validation of all the requirements stated by the users and the usefulness of the tool in the digital transformation project. The results were than analyzed, concluding that in general the tool is easy to use, with all users being receptive to the app. Moreover, from the tasks chosen to be performed by the users, in the test, it can be deduced that all the requirements placed by them were answered in the app.

Some users came with ideas to improve the app, and all of them were implemented in the tool. The comments, given during the user questionnaire after the test, were considered, resulting in the screens presented above. Moreover, after this wave of tests, and after the application was transferred to the productive environment, it was found that all departments had already added ideas of processes to be digitalized, which demonstrates the usability of this tool.

4. Discussion

To conclude, it is important to point out that this work presents two distinct contributions: to the scientific community (theoretical) and to the industrial world in practice (practical).

After analyzing the literature, it is clear that there is a lack of digital transformation strategies based on lean philosophy, and this study contributes with something new, in that it shows, a strategy that serves as a roadmap for this transition, which considers lean methodology and BPM.

Also, the literature indicates a gap concerning the technological tools that support the roadmap for digitalization, and, according to [48], [49], for this transformation to be carried out successfully, it is essential to have an action plan and the definition of objectives that are aligned with the company's strategy. Also Tortorella and Fettermann [22] stated: “The way that Industry 4.0 technologies are integrated into existing production systems and which processes they can support is still under investigation”. The DiYD app supports the phase of collecting and selecting opportunities for processes to be digitalized, also measuring indicators that allow the status of the project (digital transformation) to be perceived in what are the long-term objectives of the organization.

Therefore, this tool allows to outline an action plan for the digital transition, evaluating the value of the ICE index for each process (parameterized by the company according to its long-term objectives), since it is through this that it is concluded about the processes that should be digitalized. After this tool was developed and applied, it was necessary to perform a new evaluation, for which users, both common users and the administrator, were submitted to

usability tests to understand if it meets all the requirements mentioned by them, and its level of usability.

4.1 Theoretical implications

After analyzing the literature, it is clear that there is a lack of digital transformation strategies based on lean philosophy, and this study contributes with something new, in that it shows, a strategy that serves as a roadmap for this transition, which considers lean methodology and BPM..

Also, the literature mentions the intentions of how this digital transformation should be carried out, however, technological tools that contribute to this journey are not presented, thus validating the importance of the work developed and presented in this article, concluding that it fills the gap found in the literature.

4.2 Practical implications

After an analysis made to the industrial world, it was felt that there are few tools that support the digitalization process, so it was developed in this work a technological tool that supports this roadmap prioritizing tasks.

In this way, the work can help company managers in the adoption of the new digital paradigm, since they can see this work as an example and think of a way to adapt it to their reality, both the roadmap and the tool, in order to simplify this journey.

5. Conclusion

The pilot company where this study took place showed interesting characteristics to conduct this research because, on the one hand, it presents a high Lean implementation maturity level, on the other hand, the level of digital maturity is still very low. At this moment, it is in this very gap that it intends to act, intending to start/accelerate the digitalization process more thoroughly, in order to increase its level of digital maturity.

From the literature review it is possible to conclude that this is a situation that is common to a large volume of companies, also in the manufacturing industry. The implementation of Industry 4.0 technologies is a complex path with many challenges, namely a need for companies to develop a strategy that guides this digital transformation, in order to success in this journey [16]–[18].

The present work had the main goal of looking for ways to answer the research question: (Q1) *"How can companies initiate and/or accelerate the digital transformation?"*. To solve this question two steps were executed: the first, which was answered through the roadmap, which compiles a strategy for the success of digital transformation (answering one of the challenges proposed by the literature to the adoption of Industry 4.0 technologies), and the second, which demonstrates a way to accelerate this same strategy, from the implementation of a technological tool (filling the gap found in the literature of technological tools that support this transition).

Although it makes important contributions to both theory and practice it is important to highlight that it is not free of limitations. The fact that it was only conducted with data from a single Portuguese company, and in its context shows its limitation. Therefore, as future work, it is proposed the application of this tool in other industrial contexts in order to validate the concepts in a broader way, and the DiYD tool considers other sustainability targets (CO2, water use, waste impact), as it becomes more and more important to take environmental aspects into account in the company's strategy.

Furthermore, it would be important to study and verify the impacts of digital transformation on the three pillars of sustainability (Governance, Social and Environmental), in order to understand where it is possible to act.

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