Digitizing a Daily Continuous Improvement System: A Practical Case in a Portuguese Company

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Abstract

The growing competitiveness of the markets, combined with technological advances resulting from I4.0 increased the need for work associated with the digitization of processes, as well as the digitalization of management tools used in shop floor contexts. Thus, this paper reports a practical case in a Portuguese company, in which the objective was to create a digital continuous improvement system, which promotes data access while simplifying the current process existing in the company under analysis. For this purpose, Microsoft SharePoint® was used, which enabled the creation of a technological solution, allowing the introduction of improvement ideas, while speeding up the process of analyzing and validating them, using visual management mechanisms combined with notification systems. It should be noted that the methodology adopted was based on an iterative and incremental approach, following the principles of design thinking, in a collaborative environment and with the involvement of users. The results of this project point to the growing need for tools that already exist on the shop floor, mostly lean, to be updated from a technological perspective. The dynamic character that information and communication technologies give them, allows for greater involvement of staff, as well as more prompt decision-making.

Keywords
Industry 4.0; Design Thinking; Continuous Improvement; Suggestion system; Digitalization

1. Introduction
The growing competitiveness of markets, combined with technological advances resulting from the fourth industrial revolution, increased the need for work associated with the digitization of processes and creation of tools at all levels in large companies (Telukdarie et al., 2018). Trends such as internet of things (IoT), big data (BD) and data analytics are completely revolutionizing the way organizations operate in terms of production automation, supply chain management, lean production and quality control of their products (Kristoffersen et al., 2020). These technologies leverage several benefits for organizations, promoting the collection and processing of data in real time and enabling instantaneous adjustments according to the problems detected by the systems and production needs.

Although there are already several studies on industry 4.0 and on consensual management practices such as lean manufacturing, there are still no studies that show impacts of the introduction of these new technologies in the already established management (Buer et al., 2018).

In recent decades, the adoption of lean production practices and principles has occurred consistently in most companies, spanning different sectors and contexts. The search for implementation is based on the expected benefits that it can bring, such as cost reduction, increased quality and productivity, delivery and improved customer satisfaction (Rossini et al., 2019).

Lean manufacturing is, in its earliest form, completely independent of any type of information and communication technology (ICT). Therefore, the research effort on how lean manufacturing and ICT can cooperate to achieve better performance is essential (Buer et al., 2018).

According to Pekarčíková et al. (2019) an analysis carried out with a focus on the interdependence of lean manufacturing elements with industry 4.0, it is known that this philosophy holds great potential for a successful and sustainable implementation of industry 4.0 in the businesses. The digital paradigm is believed to improve the lean manufacturing system and move it to a much higher level of performance (Salvadorinho & Teixeira, 2021).

This paper aims to portray a practical case carried out in a Portuguese company that identified the need to digitize a large part of its processes and systems used daily. The new labor demands related to the pandemic situation, together with the low performance of some of the systems, further boosted the investment made in digital systems. The improvement suggestion system (called the daily continuous improvement system) implemented on the shop floor of the organization under study showed very low performance levels. Therefore, the company made it a priority, moving towards its digitalization. It should be noted that the daily continuous improvement system aims to give visibility to the improvement ideas identified by employees, enhancing their opinion about their workspace, and is consequently an important element in the organization's culture of continuous improvement and in the promotion itself employee engagement.

The remainder of this work is structured in the following way. After this Introduction, the Objectives of the work are presented, followed by the Literature Review constituted by the phenomenon of industry 4.0, lean tools digitalization and the data visualization importance in the digital paradigm context. Additionally, Methods that were followed in the practical case are exhibited which determine the Results and Discussion. The last section summarizes the main conclusions and puts into view some future research opportunities.

2. Objectives

This paper's primary objective is the demonstration of the digitization procedure of a lean tool, commonly used in the industrial environment. Therefore, a practical case is presented which took place in a Portuguese company with about 9,000 employees and 26 factories spread over eleven countries working in just in time in a very close way to its customers.

Given the most recent results of the daily continuous improvement system (lean tool) currently implemented on the company's shop floor and the inexistence of a suggestion system for the administrative area, this work proposed the creation of a new daily continuous improvement system integrated in a platform already used by the company. All of this without any significant financial investment. The goal is that the new solution will increase the number of implemented ideas and significantly reduce the time taken to implement each idea.

The low performance of the current system (in a physical model) was a key factor that led the company to adopt a strategy of redesigning the current system and propose a digital model. Also, the search for innovation and digitization was an impetus for the organization to initiate the digital transformation of the system.

3. Literature Review

3.1 Industry 4.0

The fourth industrial revolution, known as industry 4.0, was introduced in 2011 in Germany at the Hannover fair (Xu et al., 2018). The use of the main technologies associated with this paradigm brought companies a significant improvement in their productive capacity and efficiency, flexibility, knowledge sharing, collaborative work, cost reduction and, consequently, increased revenue (Butt, 2020).

The key technologies that stand out as the basis for the implementation of industry 4.0 are: IoT, BD, cloud computing (CC) and cyber physical systems (CPS) (Butt, 2020; Da Costa et al., 2019; Zheng et al., 2018). The IoT is a system of interconnected devices that share information collected by sensors with each other. This sharing is done through electronic communications supported by software and simplifies collaboration between employees, machines and products (Butt, 2020). The large amount of data collected allows a more complete analysis of the current situation of the company and the necessary adjustments to achieve its objectives (Butt, 2020; Xu et al., 2018). In the IoT paradigm, many of the objects that surround us will be networked, contributing to technology not be centered on traditional computers (Gubbi et al., 2013). The concept of BD is usually associated with a set of data that cannot be analyzed using conventional methods. The large amount of data collected by the IoT needs to be filtered and analyzed so that the information is useful and supports decision making. Big data analysis (BDA) is the process of analyzing a large dimension of data, seeking to identify patterns, as yet unknown relationships and trends that can be useful to accurately control performance, manage equipment maintenance timings, prevent breakdowns , and control all stages of the supply chain (Butt, 2020; Marques et al., 2020; Tupa & Steiner, 2019). With CC, large volumes of data can be housed in a public or private cloud, where can be easily shared and accessed (Xu et al., 2018). As the digitization of all processes and systems advances, the need to maximize data accessibility and synchronization has become a key factor. CC has been decisive in the information decentralization process, allowing data to be accessible regardless of the location of its target user. Its high performance combined with low implementation costs made its use indispensable in a company's digitization process (Xu et al., 2018). This technology allows you to load and store high volumes of data in cloud computing centers, eliminating the need for sophisticated and expensive hardware (Butt, 2020). CPS, on the other hand, is the primary element in the digital paradigm and is essential in building a smart factory. This kind of systems allow the interconnection of physical and computational components, mitigating the existing boundaries between them (Butt, 2020; Lee et al., 2015; Xu et al., 2018). One of the most significant advantages of CPS is the ability to exchange information between components, interpret them and activate functions autonomously (Chiarini et al., 2020; Fernandes et al., 2021). Thanks to recent developments in the industry, the availability and prices of sensors, data management systems and IT components have made CPS integration more affordable and realistic for most organizations, allowing them to remain competitive. The integration of these systems with production, logistics and services in the practices currently performed, allows the significant economic potential transformation of factories (Lee et al., 2015).

Kadir e Broberg (2021), highlight four main challenges related to human resources in the digital transition process: (i) stress triggered by the reduced autonomy in tasks, new necessary skills and information burden; (ii) safety when work is carried out in a collaborative environment with autonomous robots; (iii) changes in the cognitive loads necessary to perform the functions, reducing the weight of the physical aspect of work; and (iv) reduction of motivation for fear of unemployment and reduction of opportunities.

The main difficulty in implementing industry 4.0 technologies in organizations is usually related to the lack of knowledge and preparation. Organizations have difficulty understanding the real benefits of these technologies. Furthermore, people are usually afraid of change, and when it comes to such significant and immediate changes, they are even more reluctant (Butt, 2020; Salvadorinho & Teixeira, 2020a).

3.2 Lean Tools Digitalization

Lean production and industry 4.0 have identical goals, both seek to eliminate waste and increase productivity and quality (Buer et al., 2018). According to Tortella and Fetterman (2018), lean principles are positively associated with industry 4.0, since are capable of enhancing its performance. Sibatrova and Vishnevskiy (2016), on the other hand, point out that industry 4.0 can also affect lean approaches, eliminating barriers inherent to them. Although, lean production is usually a low-tech approach (Lopes et al., 2019), inversely to Industry 4.0, which can generate some conflict in implementations (Pagliosa et al., 2019; Salvadorinho & Teixeira, 2020b). However, the general perspective is that the literature has already created theoretical evidence that purely technological adoption does not lead to the results expected by companies. Lean production practices help to materialize organizational habits and mindsets, contributing to a revolution in organizational culture, something that favors systemic process improvements. Bearing in mind that Industry 4.0 can impact performance to a certain level, the effect can be enhanced if lean production practices are implemented simultaneously (Salvadorinho & Teixeira, 2021, 2020c; Teixeira et al., 2019; Tortorella et al., 2019; Wagner et al., 2017).

The idea of combining automation technologies with lean production is known as lean automation (LA). The concept emerged in the 1990s, but for some time it was a little explored topic. However, with the arrival of industry 4.0, new solutions emerged that increased the possibilities of combining lean production with automation technologies (Kolberg & Zühlke, 2015; Tortorella & Fettermann, 2018).

An example of LA implementation that has been in use for several years, is e-kanban. Remembering the concept, kanban is a signaling method that allows control of production flows according to the customer's needs, avoiding excess production and transport, commonly used in the type of physical cards (Kolberg et al., 2017; Ōno, 1988). Through the new ICT, it was possible to automate the detection need process and the supply of workstations. The detection of empty or missing containers can be done by the system and, depending on the degree of its development, supply flows can be triggered. Production errors due to the absence of cards also are mitigated (Kolberg et al., 2017; Kolberg & Zühlke, 2015).

3.3 Data visualization in the Digital Paradigm

The new technologies of industry 4.0 have brought a new level of connectivity that produces a large volume of varied and mostly unstructured data (Qi & Tao, 2018; Salvadorinho et al., 2020). With this, it became much easier to collect data, although the processing and extraction of relevant information from large clusters of available data became a challenge (Choi et al., 2017).

As a large part of this data is linked to real-time events, when well explored, for example using Business Intelligence (BI) tools, it can be used in adjustments to the programming and planning of business activities, reducing risks and increasing profitable margins efficiently (Choi et al., 2017). BI can be defined as the set of applications, technologies and processes that allow the collection, storage and analysis of data used to support decision making, improving the quality of decisions and accelerating this process (Chaudhuri et al., 2011; Stecyk, 2018). Through IoT, various elements can be integrated with BI systems in a variety of industrial applications (Choi et al., 2017).

Data visualization is the quickest and easiest way to convey a message, as human beings are naturally predisposed to look for patterns and relationships in everything they see (Ali et al., 2016; Salvadorinho et al., 2020). Visualization combined with data analysis allows to convert data into valuable information. With these conditions in place, decision makers are more easily aware of the organization's events (Surbakti & Ta'A, 2017).

The relevance of these technologies led to the appearance of several research works in this area. Pejić Bach (2019) conducted a study with the aim of analyzing the interrelationships between business process management (BPM) and BI, as well as the impact of using these concepts on the performance of small and medium enterprises (SMEs) in Croatia and Slovenia. Most companies find it difficult to start using these tools, mostly due to lack of knowledge, lack of human resources, motivational issues, and because they do not usually control key performance indicators (KPIs). The result of this investigation proves that companies with greater maturity in their BI and BPM systems have better performance results and, when the maturity level of both systems is aligned, at high levels, the company's performance is even higher. The same study concludes that a smooth flow of work and communication, combined with a complete way of analyzing the data resulting from existing integrated systems, allows the organization to enhance its performance and growth. However, the vast majority of SMEs are still at very low levels of maturity in these kind of subjects (BPM and BI) (Pejić Bach et al., 2019).

4. Methods

As mentioned above, the practical case presented took place in a Portuguese company. The objective is based on the digitization of a daily continuous improvement system, which is considered a lean tool widely used in manufacturing industry environment.

To reach the digitalization of the technological tool, Design Thinking (DT) (Razzouk & Shute, 2012) and Rational Unified Process (RUP) (Cooper et al., 2006) methodologies were applied, and the technological tool was developed in the Microsoft SharePoint® application using Microsoft Power Automate®.

The DT process suggested by Liedtka (2014) was the one considered as well as the iterative method of software engineering RUP suggested by Kruchten (2003). It is possible to achieve the objectives proposed for this work with a high foundation, combining a software development method with a user-centered design method. Observation was used as a tool across the entire project. In Figure 1 and Figure 2, the combination of the two methods used in the development of the application is outlined.

As can be noticed in Figure 1, a detailed analysis of the current status of the improvement system implemented was initially carried out through a sequence of informal interviews. Additionally, a weekly follow-up was carried out with the users to observe their difficulties as closely as possible. The data collected with these three observation methods culminated in the mapping of the current process using the “AS-IS” model.

Afterwards, the project elaboration phase was started, in which through brainstorming sessions the concept for the new process and respective system was created, emerging in this phase the “TO-BE” process.

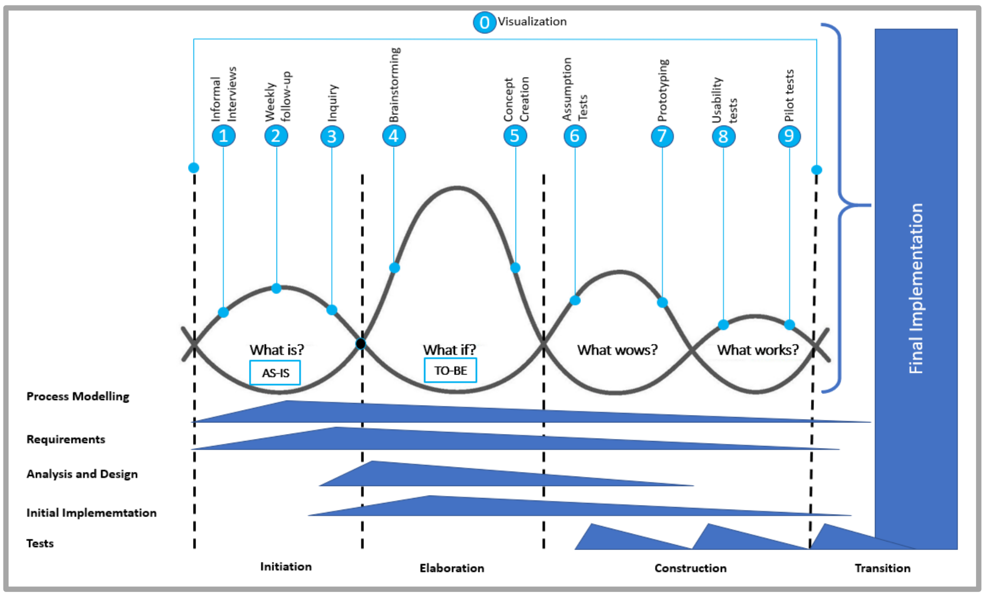


Figure 1- Practical methodology combining different approaches

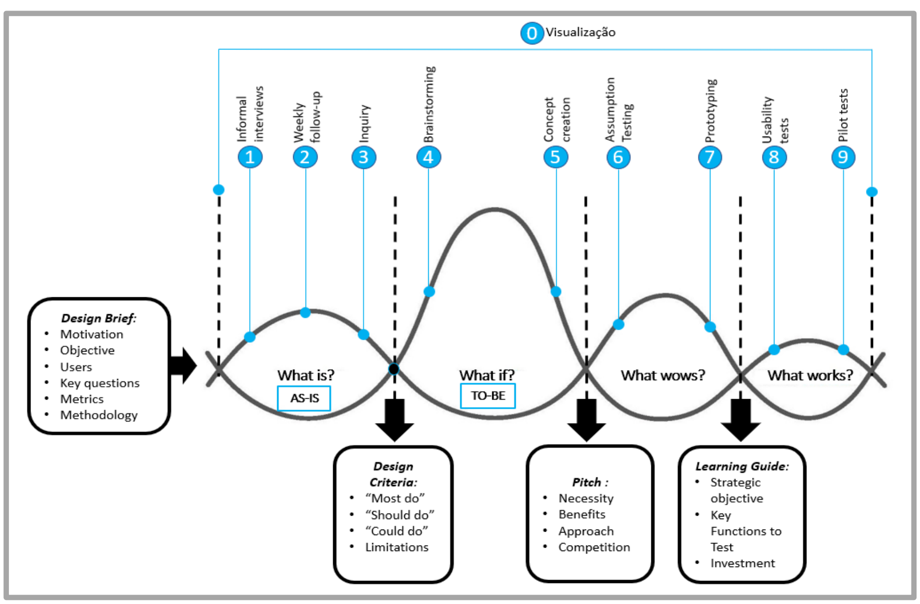


Figure 2- Tools to support practical methodology

After creating the concept, the construction phase followed, where the assumptions highlighted at the beginning of the project were tested in order to verify if the new concept responded to the defined needs. Then, prototyping was started, following an iterative and incremental construction approach, until a viable option was found that met all the previously defined requirements. Within the construction phase, usability tests and integration tests were also carried out in a pilot area in order to adjust the system to the users' needs and analyze the prototype's behavior in a real context. In order to support the process of creating the system, the tools to help project management suggested by Liedtka (2014) were also used, where in a first phase a summary of the project was made with a design brief. In the transition between "What is?" and “What if” the design criteria were used in order to prioritize the identified needs. Enter the "What if?" and the "What wows?" a concept presentation pitch was created. Finally, between “What wows” and “What works” a learning guide was used as a way of planning the tests. Figure 2 outlines the process referred to.

5. Results and discussion

After idealizing the new system in terms of the process and the main functionalities needed, practical drawings of a possible future interface were started, configuring a low-fidelity prototype. This was intended to represent a possible solution based on a set of mockups, in order to promote the validation of the concept with managers, before its implementation.

It should be noted that the prototype, through its mockups, was directed to the two main areas of the system: the homepage that shows the status of each registered improvement idea, and the submission form for a new improvement idea.

After presenting the mockup to some of the managers directly involved with the daily continuous improvement system on the shop floor, it was clear that this representation of the system was close to what was desired. From these interactions, some suggestions for improving the presented prototype were collected.

Table 1. Advantages and disadvantages of each platform

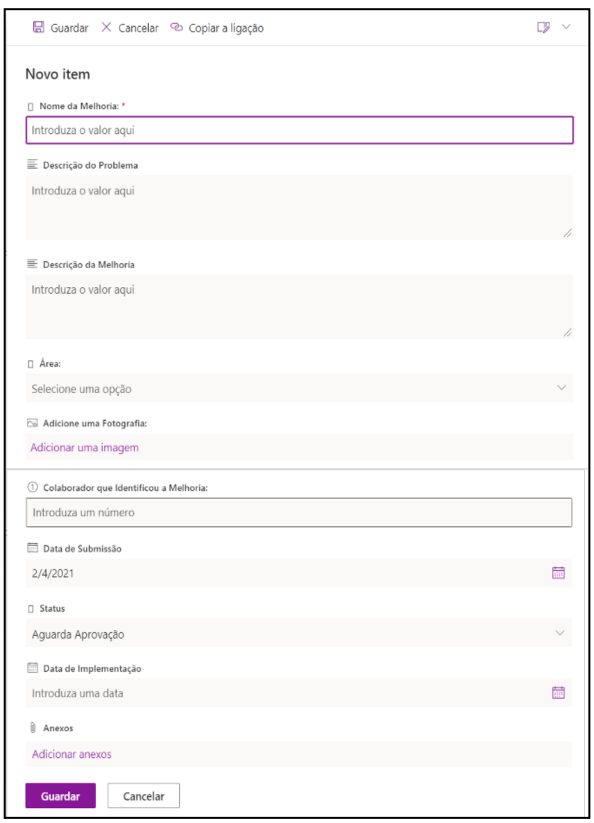
	MyBusiness.AI®	**Microsoft OneNote®**	**Microsoft Access®**	**Microsoft SharePoint®**
Advantages	Changeable status (Open, In Progress, Completed)	Integrated handwriting and drawing	Quick fill forms	Changeable status (unlimited levels)
	Launch actions through the platform	Integration of other files as preview	Dynamic information between tables	Quick fill forms
	Integrated search filters	Create actions in Outlook	Graphic representations	Graphic representations
	Quick fill forms	Mobile Version	Programmable	Dynamic information
	Automatic reporting		Create actions in Outlook	Create actions in Outlook
	Mobile Version		Data export to excel	Data export to excel
				Integrated action plan
				Mobile Version
Disadvantages	No built-in handwriting tool	Visual status management limited to two levels	No built-in handwriting tool	No built-in handwriting tool
	Viewing indicators in Qlik®	Information is not dynamic	There is no mobile version	Has already been used on a system that is inactive
	Action management can only be done through the platform	Graphics must be fed manually	Unintuitive about system changes	Limited knowledge of potentials
			Limited knowledge of potentials	

One of the conditions for the development of the new digital system was to find the solution in one of the systems already used by the organization. In this sense, it was necessary to do a research on all the systems used and to understand which ones could meet the needs of this new technological tool. This first analysis resulted in four possibilities: MyBusiness.AI®, Microsoft OneNote®, Microsoft Access® and Microsoft SharePoint®. To choose the platform, a detailed assessment was made, highlighting the advantages and disadvantages of a set of possible alternatives. Table 1 summarizes the result of this analysis, based on the assumptions defined for the new system.

A decision matrix was created in order to decide from all applications which one is most capable of meeting expectations. The criteria used were based on the following characteristics: ability of the application to be user friendly, platform development, visual management, data access, KPI's integration and flexibility.

After some tests were carried out on the functionality of the Microsoft SharePoint® platform and the process automation system, it became clear that they responded to the expectations for the new digital daily continuous improvement system, fulfilling all previously defined goals. Thus, a prototype was built with enough detail to be used in the testing phase, in the context of the shop floor.

Initially, the submission form for a new improvement idea was built. The form (Figure 3) contains three fields that should not be filled in by employees when submitting a new improvement idea: 1- "Submission Date" ("Data de submissão"), which corresponds to the date the idea is entered into the system, this data being automatically filled in by the system ; 2- "Status", which corresponds to the stage in which the improvement idea is and which is also automatically filled in by the system with the default "Waiting for Approval" ("Aguardar Aprovação"); 3- "Implementation Date" ("Data de Implementação"), which is the date on which the improvement idea is implemented and there is no longer any task associated with it pending, which is also automatically filled in by the system. These fields are very relevant as they include information that will be followed in KPIs. Through the difference between the "Submission Date" and the "Implementation Date" it is possible to obtain the number of days that the implementation lasted. The "Status" field will also represent the number of ideas that are "Awaiting Approval", "In Implementation" and "Implemented".



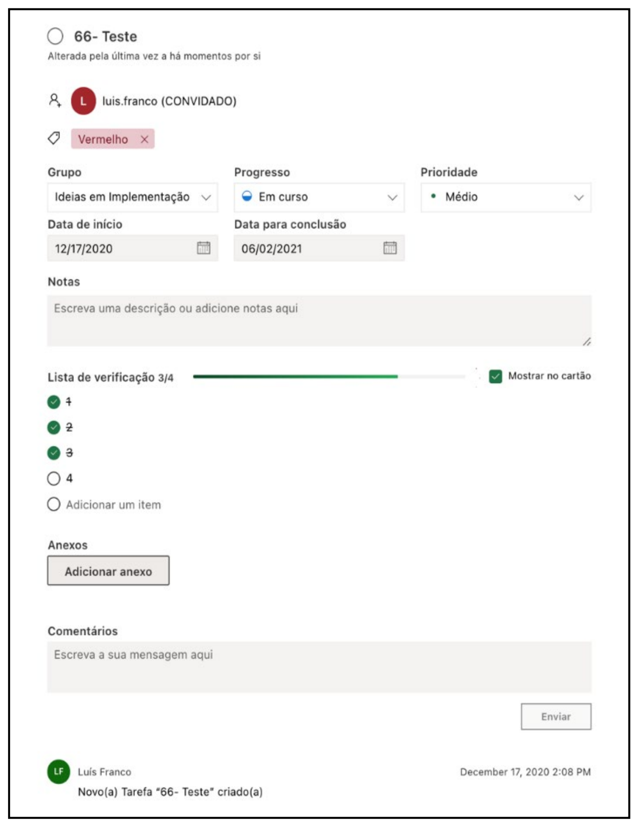


Figure 3- Submission form for a new improvement idea
(Interface in Portuguese)

Figure 4- Kanban Board Improvement Idea
(Interface in Portuguese)

The improvement idea submission form automatically generates a list that records the details of the various ideas entered the system. This overview page corresponds to the initial of the system, showing in the center a preview of the ideas entered and a button that is distinguished from the rest of the page, with the designation "+ New" ("+ Novo"), which allows you to open the idea submission form, with the possibility of adding new ones to the list (Figure 5). In addition to the list of ideas for improvement in the center of the page, on the left side there is a fixed menu with direct access to three tabs: "Submit an Idea for Improvement" ("Submeter uma Ideia de Melhoria") that directs the user to the homepage itself; Qlik® which allows access to a webpart with the KPIs referring to the system; "Status" that gives direct access to the kanban board.

The table, in addition to the macro view with the name of the improvement idea in its respective stage, allows you to open each one of them in a detailed view (Figure 4). Within the card dedicated to each improvement idea, it is possible to assign the implementation of the same to an employee, fill in their progress, add a priority indicator, set a start and end date for the implementation process, add notes, lists of verification with the various necessary steps to be taken during implementation, attachments and even a comment area. All data filled in on an improvement idea card are registered in the system in real time, being immediately visible to any user with access to the kanban board, regardless of the device used or its location.

The kanban board was one of the main expectations for this new system. This type of representation allows any participant to quickly know the status of a specific improvement idea and at the same time visualize the number of ideas that are in each of the possible stages. Given the flexibility offered by SharePoint® in assignments and number of stages, it was possible to build the framework according to the exact needs of the project (Figure 6). Four possible stages were created for an improvement idea. The first one called "Pending Ideas" ("Ideias Pendentes") is intended for ideas inserted in the system, but which are still awaiting an evaluation by the superiors. The second for "Ideas in Implementation" (Ideias em Implementação"), which includes all those that have already been evaluated and validated by management and that are already in the implementation phase. The third and fourth stages are dedicated to the finished ideas, whether they are "Implemented Ideas" ("Ideias Implementadas") if they were approved in the first stage or "Rejected ideas" (Ideias Rejeitadas") if they were discarded. Ideas can be moved between the different stages with a simple drag and drop.

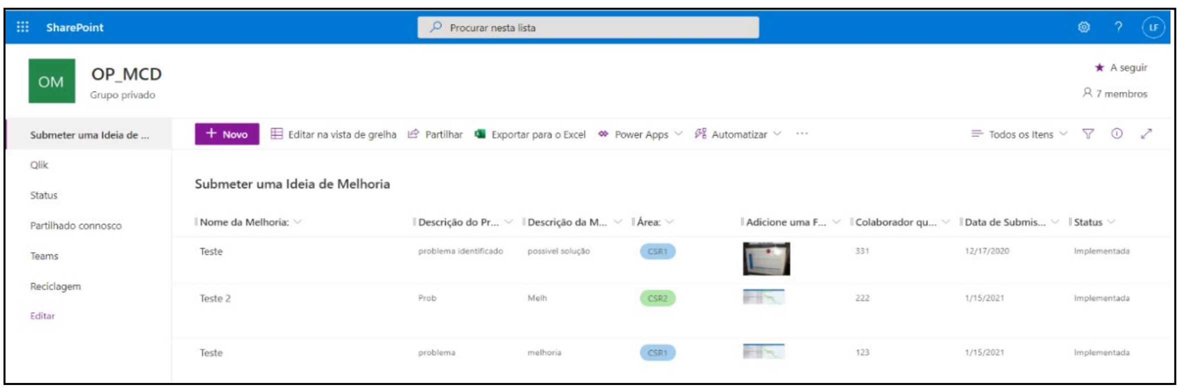


Figure 5- System home page in Microsoft SharePoint®
(Interface in Portuguese)

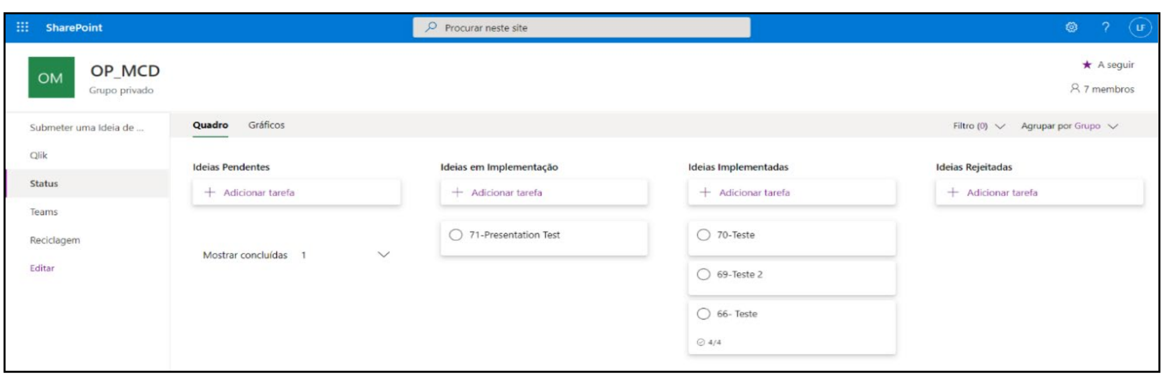


Figure 6- Kanban Board for Microsoft SharePoint® Improvement Ideas
(Interface in Portuguese)

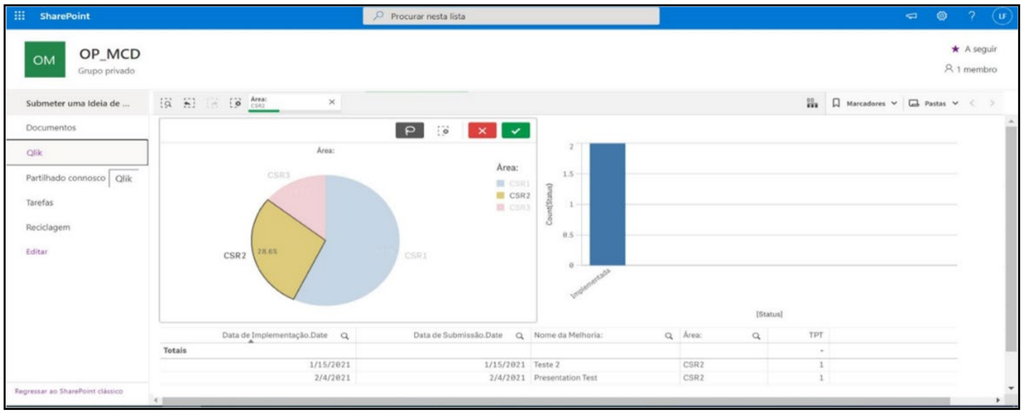


Figure 7- Kanban Board Improvement Idea
(Interface in Portuguese)

Finally, with the main areas of the system built and the flow of notifications and approvals built, the data presentation environment in Qlik® was developed (Figure 7), where all the information collected through the Microsoft SharePoint® list is compiled and processed to present it in form of KPIs. With the new digital system, the time needed to insert an idea for improvement has increased, making it quicker to register on a paper form than using a tablet. However, it is believed that this difficulty will be overcome by increasing the learning curve and familiarity with the tool and application. Although the new system eliminates printed forms and writing material dependencies, it depends on the tablet's battery and internet connection. Despite this, it should be noted that, in addition to a significant reduction in paper consumption, the new system allows the introduction of data in different formats, namely media files and photographs.

The new system also enhances all the opportunities that a digital system promotes that are not possible with conventional physical systems. These opportunities include accessibility to data/information regardless of geographic location, the possibility of real-time tracking of the status of the improvement idea, and even the automatic generation of KPIs. Approval flows are also automated, making it more agile and clear for all employees, with automatic notifications to key stakeholders at each stage of the process. The decentralization of the system of a physical board also makes the number of trips necessary to suggest and implement an improvement idea to be significantly reduced. The main contributions of the system's technological update are summarized in the Table 2.

Table 2. Main contributions of the system's technological update
Legend: x- absent characteristic; √ - present characteristic

Characteristics	**Physical Daily Continuous Improvement System**	**Digital Daily Continuous Improvement System**
Form filling time	30s	50s
Insert media Files	x	√
Accessible from any location	x	√
Detailed traceability the idea	x	√
Automatic competition of KPI	x	√
Real time notification	x	√
Physical framework in the area	√	√
Reduced the paper used	x	√
Automatic archive	x	√
Optimized approval flow	x	√
Number of moves in a simple implementation (no scaling)	6	3

6. Conclusion

With the digital continuous improvement system developed in Microsoft SharePoint®, with flows based on Microsoft Power Automate®, it was possible to validate the feasibility of using digital systems on the shop floor. Following a collaborative methodology, the ideal combination of human interaction with technology was found, a principle reinforced by Ōno (1988) and Kadir e Broberg (2021). The digital system was developed in a practical and collaborative environment, involving users in order to ensure their requirements, while guaranteeing their expectations, as defended by Liedtka (2014). Thus, several informal interviews and tests of the solution were carried out, following a user-centered approach in an iterative and incremental development paradigm.

Through this investigation, it was possible to reach the main objective, the creation of the daily continuous improvement system in line with the principles of digitalization and industry 4.0 trends. This new system, in addition to being digital, should encourage the involvement of employees with it in order to increase the number of suggested improvement ideas and reduce its average implementation time. Throughout the project, the monthly average number of ideas for improvement suggested in the current system increased due to the high monitoring given to employees. Additionally, to the increase of improvement ideas and implementation time, this digitalization process fostered the communication flow, removing paperwork and making people capable of tracing their submitted ideas.

The methodology of this work intends to denote a starting point for the digitization of existing systems on the shop floor and based on lean principles. Also, the practical case carried out demonstrates that through structured development, it is possible to take full advantage of available resources and that external solutions are sometimes sought with high costs, when the necessary conditions for change exist within the organization.

In this way, it was possible to materialize the idea reflected in the literature that the digitization of lean tools provides an increase in the performance of the lean paradigm. Furthermore, the paper intensifies the idea that the implementation of industry 4.0 related technologies benefits from a lean shop floor.

It is intended, in the scope of future work, to transport other lean tools to the digital world, in order to establish digitization methodologies, capable of being followed regardless of the context.

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