Open-Source Innovation in Practice: A Lean-Based Development Process Leveraging Open-Source Big Data Tools

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Abstract

Innovation depends on the exploitation of market potential with products that are aligned with customer needs. However, building innovative products is becoming gradually more challenging because of increased market volatility, uncertainty, complexity and ambiguity. In our Innovation Lab, inside an e-Procurement Company, we encountered several challenges when implementing an innovation process to develop an initial unstructured data processing Minimum Viable Product (MVP) based on open-source big data tools: (i) raising and prioritizing user demands; (ii) deciding about adequate tools; and (iii) understanding how to promptly set up a viable product. In this paper, we share our open-source innovation experience in bringing novel solutions to an oil company's suppliers. In general, we present and discuss how we have been applying our innovation process to create MVPs, and which technical decision helped us accelerate the MVP development in the presence of a large-scale, unstructured database and open-source big data tools. Overall, we believe the proposed lean-based development process can help practitioners and researchers who want to understand and improve their knowledge about lean products, how to build MVPs, and advance open-source innovation involving big data tools.

1. Introduction

Developing software products and demonstrating their value can take several years [4]. However, ever-changing business opportunities demand development lifecycles with short experimentation periods. However, in many cases, these opportunities lead to the creation of software products that are not worthwhile at the end of the development lifecycle [5]. Consequently, implementing a feedback-based environment, dedicated to delivering initial software releases that comprise the minimal value can reduce the chances of unsuccessful investments. As an interactive proposal, the Minimum Viable Product (MVP) [6] initiative relies on a central premise: to collect the features that are essential in an at-least functional software product that can add business value, and that can be effectively used and validated by end users as a viable product.

The substantial challenge for innovation and development projects is the exploitation of market potential with products that are aligned with customer needs [11]. Developing a product that meets the customer needs as precisely as possible requires effective requirements management [30]. Innovation processes include the transformation of customer needs into detailed technical requirements at the beginning of a project. There is also the need to include handling of relevant requirements during the development process. A frequent cause for wrong decisions and late process iterations is missing customer values and needs and missing specific project objectives. Indeed, even if customer requirements are known, they often lose focus during development projects.

The development of successful new products and services is a challenging activity that is crucial to the survival of a new venture [29] [31]. Creating new products and services, and finding a suitable business model is becoming increasingly challenging due to increased market volatility, uncertainty, complexity and ambiguity [8]. Maintaining a competitive advantage in research and development requires increases not only in effectiveness, but also in the efficiency of research

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and development efforts. Significant product differentiation also needs to be achieved under a reduced deployment of resources [28].

In this context, our Innovation Lab, inside an e-Procurement Company, was given the challenge of discovering how the company could increase the value delivered to the suppliers that use our platform. The challenge needed to be overcome in eight weeks, which was commonly referred as our "timebox." The platform is used by Oil Companies to publish their demands in the form of unstructured documents. Suppliers search these demands in order to decide whether to fulfill them. The e-Procurement Company currently aims to improve the satisfaction of the Oil Company's suppliers and expand its market possibilities with novel solutions focused specifically on the supplier side.

The Innovation Lab is a recently formed team involving innovators with different abilities: software developers, designers, marketers and sellers. As a team, our goal was to radically change the process that had unsuccessfully been used to bring innovative solutions to the supplier chain market. Because of this lack of success, the e-Procurement Company's executives decided to embrace a more customer-centric process. The proposed development process was inspired on Gartner's framework [7] and others [4] [5] [6]. The Lab's framework is divided in two phases: The Immerse phase, in which the team focuses on learning about the subject, and the Develop phase, in which the ideas are put into validation. The Immerse phase was heavily influenced by Design Thinking methods, while the Develop phase was mostly influenced by the Lean Startup methodology.

In this paper, we share our experience of adapting an innovation process to bring novel solutions to our clients – the Oil Company's suppliers. The process aimed to assess several hypotheses that can be tested only by experience. Moreover, having a clear focus on the needs of early customers by building a product and service iteratively based on their feedback reduces the market uncertainty and failure rate [6].

We faced many challenges in implementing our process to develop an initial unstructured data processing MVP based on open-source big data tools. They include business related ones, such as raise and prioritize user demands, and also some more technical ones, such as having to decide which tools are more adequate and how to promptly set them up a viable solution. In the end, we overcame the challenges, successfully consolidated the innovation process, and delivered in eight weeks a novel solution to a previously unsolved relevant problem. We believe that our experience in adapting an innovation process is beneficial in that it can help practitioners and researchers who want to understand and improve their knowledge of open-source innovation. For example, output-driven thinking is a common reason for startup failure. Instead, the focus put on **how** to build something most efficiently should shift towards **what** should be built to create value for customers. It is necessary take a step backwards to better understanding the problem to be solved. This paradigm shift implies moving away from solution-focused and output-driven thinking to **value creation thinking**.

The main contributions of this paper are:

- Describing a process to raise and prioritize requirements from users by directly interacting with them;
- Presenting how the team planned and managed to deliver the first two phases, "immerse" and "develop," by the end of its eight-week project;
- Using an open-source big data tool to quickly validate a solution's technical viability and value delivery to the customer.

This paper is organized as follows. Section 2 presents the background on lean innovation and new technologies. Section 3 presents related work. Section 4 presents an overview of the innovation lab process. Section 5 describes and discusses the use of an open-source big data tool to validate the created MVP. Section 6 presents how the innovation lab team collected user feedback. Section 7 presents the results of the data analysis performed on data generated by the MVP. Section 8 discusses challenges and future directions, and Section 9 presents our conclusion and future work.

2. Background

In order to lay the foundation for the rest of our paper, in this section we provide some background on lean innovation, lean startup, lean inception, and give an overview of design thinking and on open-source big data technologies such as Elasticsearch.

The traditional innovation process model is based mainly on the linear methodology of extensive planning, and strives for perfection until market launch [32] [33]. The lean innovation model uses the minimum viable and quickly testable product concept, primarily under real market conditions. One idea is to refine the initial concept with speed and low cost by learning from market interactions.

The Lean thinking [27] is an improvement philosophy that focuses on the creation of value and the elimination of waste, and it is a potential weapon in this struggle. Lean thinking has been a subject of research for nearly two decades, the focus of which has been on improving manufacturing processes [14], as well as administration, management, and the supply chain coordinator. However, new engineering products continue to underperform in their lead times, cost and quality.

The Lean Startup [6] is a group of processes that help entrepreneurs to develop products. These processes demonstrate that it is necessary to shorten the build-measure-learn cycles in order to increase the chance of providing the right solution to customers. Most startups fail because they waste time and money building the wrong product before realizing it is too late to understand what the right product should have been [20] [21]. A Lean Startup is launched as soon as possible with a proof of concept, also called a "minimum viable product" (MVP), a basic product that includes only enough resources to allow feedback from early users [19]. The company continues hypothesis testing with a product succession incrementally from version refinement.

The Lean Inception is a methodology focused in a collaborative work to align people in regard to the MVP to be built. This methodology developed by Caroli [2] comprehends a group of activities that are inspired on Design Thinking techniques [9] with a Lean Startup [6] approach. A lean creation is useful when the team needs to iteratively develop an MVP [2] [22]. Although the term is often misunderstood, the central property of an MVP is that it is something we build to know if it the final product is worth building [23] [24]. Therefore, we were able to choose features based on testing our assumptions of what is valuable to users. To do this, we need to understand who our users are, what activities they perform and what the product supports, and how to measure if the product is useful.

Design Thinking [9] is a technique to solve problems based on a cognitive process used by designers. The technique starts with an empathy phase, in which the key concerns of the users are raised. Then, in the ideation phase, divergent and convergent tools are alternately used to generate ideas of solutions and prioritize them. Finally, in the prototyping phase, a model of the solution is developed in order to collect user feedback from it.

Regarding open-source big data tools, Elasticsearch is an open-source full-text search engine written in Java that is designed to be distributive, scalable, and near real-time [15]. The Elasticsearch server is easy to install, and the default configuration supplied with the server is sufficient for a standalone use without tweaking, although most users will eventually want to fine tune some of the parameters [16]. All data in Elasticsearch is stored in indices. An index in Elasticsearch is like a database in a Relational Database Management Systems (RDBMS): it can store different types of documents, and update and search. Each document in Elasticsearch is a JSON object, analogous to a row in a table in an RDBMS [17]. A document consists of zero or more fields, where each field is either a primitive type or a more complex structure. A document has a Document type associated with it; however, all documents in Elasticsearch are schema-free, which means that two documents of the same type can have different sets of fields. Document type here is similar to the RDBMS notion of a table: it defines the set of fields that can be specified for a particular document [18].

3. Related Work

This section presents some of the published literature related to this article. Initially, we present the work involving to the creation of the lean concept, inspired by Toyota. We also present a research that creates frameworks for applying design thinking and lean innovation. In addition, we present works that sought to perform customer value mapping in a holistic, dynamic and transparent manner.

The authors in [13] present the Toyota Product Development System, which brings new and innovative products to market rapidly and constitutes a key competence for any successful consumer-driven company. All industries, especially automotive, are slashing product development lead times in the current hyper-competitive marketplace. Through examples and case studies, this research illustrates specific techniques and proven practices for dealing with challenges associated with product development, such as synchronizing multiple disciplines, multiple function workload leveling, compound process variation, effective technology integration, and knowledge management.

In [3], the authors define a framework that integrates Design Thinking, Lean Startup and Agile Development as three different phases, respectively Generate, Develop and Transfer, to provide a complete cycle to develop new solutions from scratch. In our approach, we modified the first two phases, generate and develop, and then passed the acquired knowledge to an agile development team to move forward.

In [11], the authors introduce a lean innovation approach and focus on a framework for mapping customer value in a holistic, dynamic and transparent way. This framework addresses several critical aspects in product development and, as a consequence, it enforces a clear definition of requirements regarding product and process at the beginning of every project.

In [25], the authors investigated the applicability of lean production to a software services firm and concluded that the lean software projects performed better than non-lean ones. The authors examine the applicability of lean production to knowledge work by investigating the implementation of a lean production system at an Indian software services firm. They discuss specific aspects such as, task uncertainty, process invisibility, and architectural ambiguity. In addition, the authors demonstrate by means of an empirical analysis that the implementation of a lean production system in knowledge work is possible and that it changes how the organization learns through hypothesis-driven problem solving, streamlined communications, simplified process architectures and, to a lesser degree, specified tasks.

This paper [26] is about how to get the most out of product development. The authors present some strategies for creating new products that share key components and try to ensure that each product is different enough to attract different customer profiles. Thinking about multiple projects increases the chances that the organization produces a stream of new products that span multiple market segments. Projects that share components and engineering teams can deliver many products quickly and utilize new technologies. To make this possible, special organizational mechanisms and processes are needed.

The author in [34] presents a study about the underlying engineering principles Toyota uses to develop vehicles and shows how they can be applied to software development. The research argues that when applied correctly, lean software development results in high-quality software that is developed quickly and at the lowest possible cost. Moreover, the success of many of the practices of agile software development can be explained by understanding the principles of Lean software development [35] [36].

4. The Innovation Lab Process

As described previously, our lean-based development process involves *Immerse* and *Develop* phases.

In the Immerse phase, the innovation team started an activity to study the end-to-end process of a sale made by a supplier by conducting interviews with the organization's employees. The employee selection for these interviews was based on the requirement that the employee met at least one of the following criteria: (i) had contact with Oil Company's suppliers on its current function at the Procurement Company; (ii) had previous contact with Oil Company's procurement as a supplier or (iii) had contact with Oil Company's procurement process as a supplier at the Procurement Company, since the company itself is an Oil Company supplier. These interviews provided the material to develop a draft of the user journey that would guide the rest of the Immerse phase.

The next activity was focused on bringing suppliers to actively engage in the process. As the e-Procurement Company owns the platform that intermediates the relationship between buyers and suppliers, the innovation team had access to data related to supplier's behavior. Key insights were extracted from a database, such as the number of transactions that each supplier had engaged in between October 2018 and March 2019, and the total amount of money involved in these transactions. Based on the information extracted from the data, the innovation team split suppliers into two groups – active and inactive. Indeed, a group of suppliers had registered on the platform but hadn't engaged in at least one transaction during the given period, and this group of inactive suppliers was excluded from the sample. Then, the group of active suppliers was split into three groups: "light user supplier," "middle user supplier" and "heavy user supplier," based on the number of transactions that each one engaged. A "light user supplier" was engaged in a few transactions, while a "heavy user supplier" was engaged in a large number of transactions.

Considering that the resulting solution had the goal of improve supplier's satisfaction with the e-Procurement Company, the innovation team chose the "middle user supplier" to engage further in the process, assuming that this group would constitute an average of all three groups. A random selection of suppliers inside of this group was made, and those selected were invited to join a dynamic hosted at Procurement Company's headquarters. Relying on two mediators from a third-party company, the dynamic proposed some group tasks, to help the innovation team understand more about the suppliers and engage them in further activities.

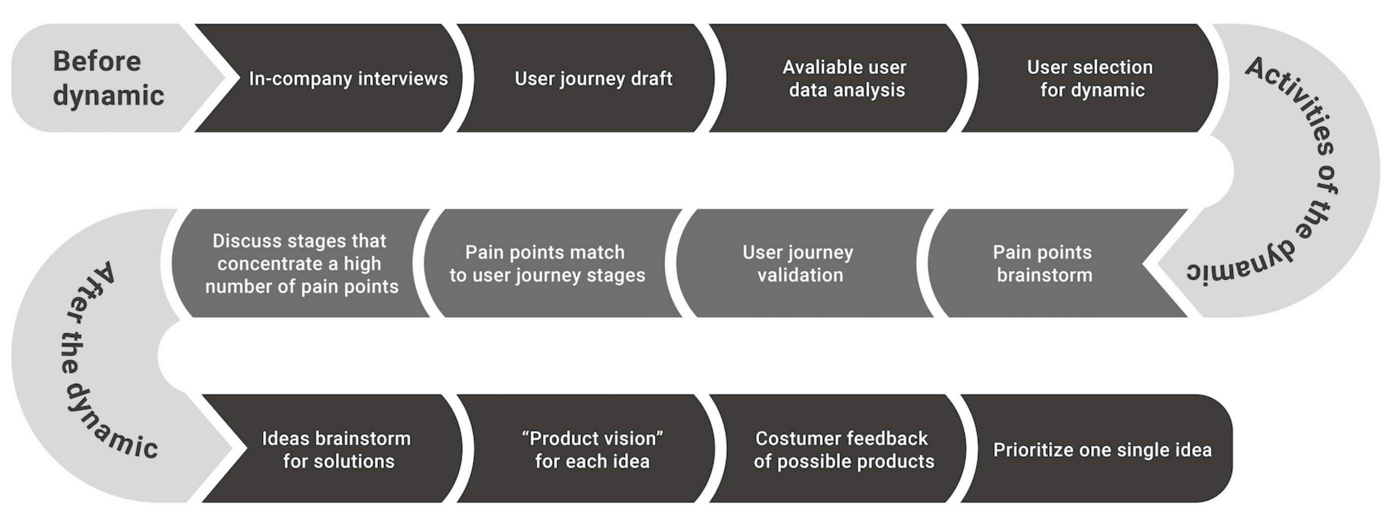

Figure 1: Activities of dynamic with users.

Figure 1 presents the sequence of activities used to guide the dynamic with the suppliers. During the dynamic, the first activity proposed was a brainstorm of pain points in any stage of the procurement process. As a diverging activity, its goal was to generate critical mass to be analyzed later, and also try to register a pain point that was not clearly related to a single stage of the user journey drafted by the team. After collecting pain points from sticky notes and putting them on the board, the mediators, with the support of the innovation team, started the second activity, which was meant to present and validate the user journey. The mediators drew the user journey, as shown in Figure 2, on the board and explained each stage to the suppliers. The third activity, a converging one, aimed to group pain points with their related stage on the journey. By picking each sticky note, reading it out loud for the group, and discussing its content and its position on the journey, the innovation team was able to take valuable information from its target customer. By the end of the third activity, the board showed the user journey's stages with only a few sticky notes, showing that there were no main pain points there. It also showed the stages where a large number of sticky notes were concentrated, indicating the stages where the innovation team should focus its efforts to maximize solution impact. The fourth and last activity was an open discussion about the stages that had a high concentration of sticky notes. This discussion was meant to create as much data as possible about the common pain points of these stages, which were the stages that would be further investigated by the team.

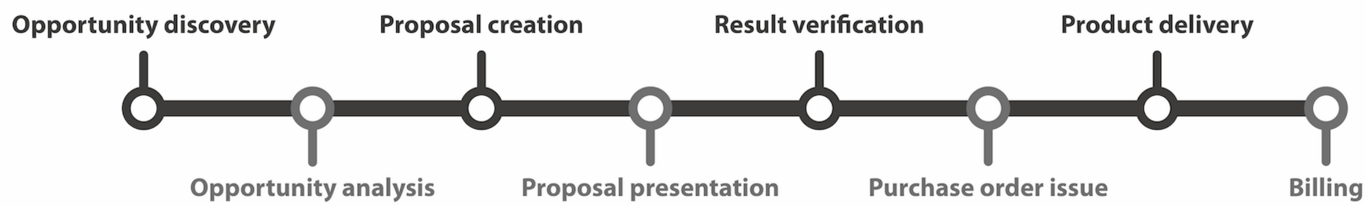

Figure 2: User journey stages.

Provided with the data generated by the dynamic, the innovation team started the activities aimed to generate and prioritize possible solutions for the suppliers. The team engaged in a brainstorm of possible ideas of solutions for each stage of the user journey where a large number of paint points was concentrated. After an open discussion within the team, eight ideas were prioritized, and their feasibility and possible impact for the suppliers was considered. Then, using the Product Vision tool from Lean Inception methodology [2], descriptions of the ideas as products were generated, making them easier to understand. The innovation team used these descriptions to request feedback from the suppliers that attended the dynamic, asking them to rate their willingness to use the product and also to give suggestions for improvement. Through the analysis of the data from this feedback, the innovation team was able to prioritize one single idea.

In the Develop phase, the selected idea was related to the "Opportunity discovery" stage of the user journey. In this stage, the suppliers must search for opportunities inside the platform, and determine whether they are relevant to them. They are also notified by email, based on specific groups in which they are registered. These groups were created by the Oil Companies in the past to put together similar products inside a specific group. So if the supplier provides any product contained in a specific group, this supplier should be registered as a supplier of that whole group.

Both ways to discover opportunities present critical issues for the suppliers. The proactive one, searching through the platform to check recently published opportunities, does not search through the attached files of an opportunity. The information needed to check the relevance of an opportunity is always hidden inside these files, so the supplier must download every opportunity that seems interesting and manually check for information on multiple resources. The email notifications, considering its targeting by family, ends up bringing irrelevant notifications of opportunities that do not fit with the supplier business.

To tackle both problems, the innovation team designed an MVP that facilitates the search for opportunities considering the content in the attached files. The MVP also sends notifications whenever a new opportunity relevant to the supplier's business gets published, considering the search made previously by the supplier.

5. The MVP

This section presents the MVP, which consists of a cloud-based architecture we built that relies on several open-source tools available in the internet, which can be quickly customized, and aims to support rapid prototyping process.

Figure 3 presents the MVP architecture, which includes three main components a: Java Web Application (JWA), a MySQL database and an Elasticsearch component. The JWA is responsible for getting the data from the e-Procurement Company API currently being used by the main platform. This process happens periodically and can be divided into three steps. First, the Java Web Application send requests to get all available data, including attached files, from new opportunities. Second, the JWA extracts all content from the attached files and creates a single JSON object for each opportunity. This JSON object contains the structured data from the opportunity and the content extracted from the attached files. Finally, the third step involves data persistence. The JWA sends the JSON object to the Elasticsearch component, which is responsible for the opportunity indexation.

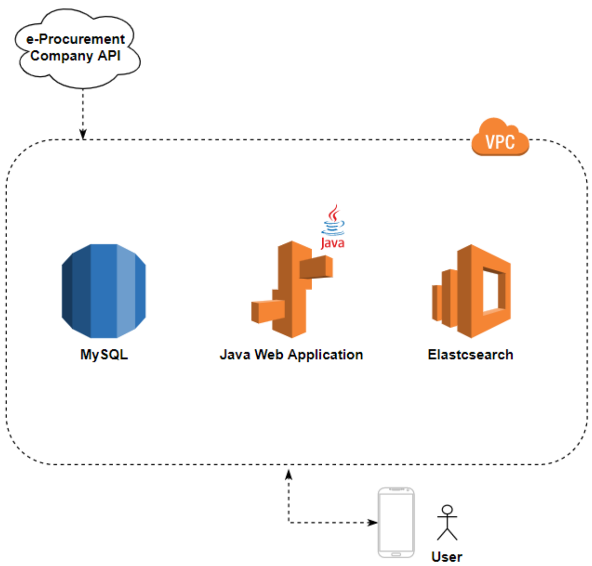

Figure 3: MVP Architecture.

The Elasticsearch is an open-source search mechanism, built on top of Apache Lucene [10], commonly used for handling queries into non-structured data. It can be considered the most important part of the architecture as it manages to rapidly query for keywords inside the opportunities, retrieving a list of results ranked by their relevance to the inserted keywords, without any previous preparation of the data. This functionality enabled the innovation team to quickly test the technical viability of this kind of search, without spending much effort dealing with the complexity of the data.

The users interact with the MVP through a responsive Web page, developed with a mobile first approach, to maximize the time that the users are able to interact with the product. This Web page communicates with the Java Web Application, which sends queries to the Elasticsearch and stores and retrieves some user data from a MySQL database.

Every user interaction with the MVP was logged in the MySQL database, thus creating an important data source of user events to be further analyzed. The first version of the MVP was released to the suppliers and some upgrades were made based on their feedback.

6. Gathering User Feedback

The primary goal of the MVP was to validate whether the final product, which was not built yet, could provide real value for real users. To estimate this indicator, the team sought feedback from suppliers, regardless of whether they had participated in the Immerse phase. The feedback gathering was divided in two phases – the team used telephone calls in the first phase and emails in the second phase to reach the users. The phases presented different efficiencies in getting feedback considering the team's effort.

During the first phase, the team made telephone calls for every supplier that participated in the dynamic during the Immerse phase. The idea of reaching users by phone was to give them a chance to interact more openly, thus collecting more insights for the product. However, the results were not the ones the team was expecting. No great insight was collected because the users tended to interrupt the phone calls as fast as possible. The overall efficiency of the process was also disappointing. The team tried to reach 21 users and, while 15 of them answered the call, only 3 answered the questionnaire proposed by the team.

Considering the unsatisfactory quality of feedback, the team decided to improve the communication method. By sending online questionnaires via email, the team switched a personal and laborious approach to a much more impersonal and effortless one. The team sent 1300 emails to suppliers that did not participate in the previous dynamic. By checking the dashboard provided by the platform used to send the emails, the team registered that 439 suppliers opened the email. Of the ones that opened it, 19 have responded the questionnaire.

Comparing the two approaches, an external observer might conclude that using phone calls is much more efficient than sending emails. The first method shows a conversion rate equals to 14% (3 responses after 21 phone calls made) compared to a conversion rate lower than 2% (19 responses after 1300 emails sent) with the second one. However, these rates do not show the amount of effort spent on each one of the approaches. The team estimates that it spent less energy to prepare and send the emails than to make the phone calls.

7. Data Analysis

After collecting user feedback through phone calls and emails, combined with the log generated by user interactions with the MVP, the team had the necessary data to confirm the value proposition hypothesis, that is, whether the final product was worth building.

The main question the team wanted answered was, "How frequently would you use this solution?" Figure 4 presents the percentage of the answers given by the users. A high percentage of users said that using the tool regularly was necessary for any further monetization.

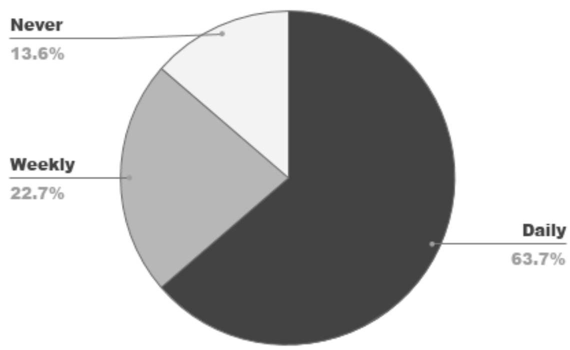

Figure 4: Responses to the question, "How frequently would you use this solution?"

The results for this question were considered quite satisfactory. 63.6% of the users who answered the survey said that they would use the solution at least once a day and 22.7% said they would use it at least once a week. Only 13.6% said that they would not use the solution. Adding up the ones who would use it daily with the ones who would use it weekly, we ended up with 86% of users willing to use the tool with a considerable recurrence.

The logged interactions also showed that the users were willing to use the tool. Figure 5 shows the quantity of users that interacted with the tool, grouped by their use.

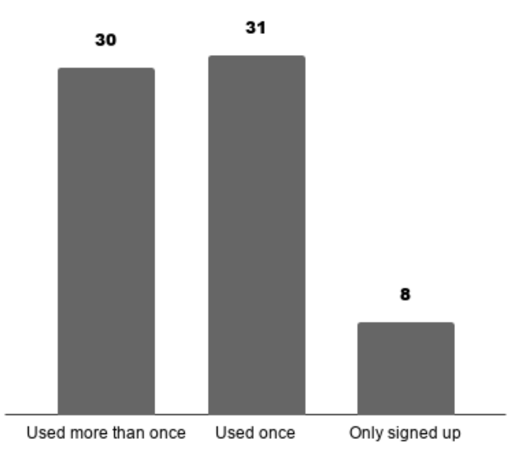

Figure 5: Quantity of users grouped by their interaction with the tool.

The logs registered that 69 users signed up for the tool. As Figure 5 shows, only 8 of them did not try to use the search mechanism, which means they only signed up but did nothing else. From the 61 that have actually tested the tool, 30 came back at least once after their first try. Considering that the MVP did not present the level of user experience that is expected for a market tool, the results from the user interactions were also considered satisfactory by the innovation team.

8. Challenges and Lessons Learned

This section discusses the challenges, solutions and lessons learned derived from the design and implementation of the practical application presented in the previous section.

a) Challenge: Applying the innovation lab process to create MVPs

The Innovation Lab was designed to apply rapid MVP development concepts for hypothesis validation without a high development cost. However, some additional efforts and improvements in creating a lean-based innovation process were needed to achieve this goal over eight weeks of work and to validate the hypothesis.

Solution: The innovation lab process was created based on lean and design thinking methodologies. By applying these principles, we can facilitate and eliminate the greatest number of uncertainties during requirements gathering and prioritization as we interact directly with users. To make this possible, we created an Immerse phase in which we conducted interviews with employees of the e-Procurement Company. These interviews provided the information to develop a user journey sketch that would guide the rest of the Immerse phase. In addition, we had suppliers actively involved in the process, which made it possible for us to close the cycle in eight weeks.

Lessons Learned: First and foremost, senior management must be committed to adopting the innovation process. After all, it will be responsible to define the flow of processes and to remove any impediments. In addition, management must act in conflict management and align with the traditional part of the organization to avoid inhibiting the agility of the lean team. Our goal in developing MVP using a lean-based approach was to deliver value and, because of this, we had as main objective the validation of hypotheses through experimentation. The process was built in a simple way, with the idea always focused on building, measuring and learning. Thus, it was possible to quickly realize the changes in scope that were needed to achieve the desired goal.

We also noted the low cost to validate hypotheses, as we were able to test the feasibility of product design in a leaner way. In addition, ongoing learning was measured by the quality of results and feedback from suppliers.

Another factor that contributed to the success of the process was the ability of the lean method to adapt to constant changes in the environment, as it allows for the system to be built fast, generating confidence in those involved in the process. With this, we saw that the process allowed us to identify new opportunities, create prototypes and collect frequent feedback from suppliers.

b) Challenge: *Perform searching in unstructured data*

While search through structured data is not a problem anymore, unstructured data is still considered a major technical challenge [16] [17] [18]. Many people, even some with an IT background, believe that only specialists can work with the tools designed to handle the challenge of searching through unstructured data.

Solution: Our team started by researching methods and tools that could be applied to this problem. Focusing on open-source resources, Elasticsearch quickly appeared as a solution that was not only able to provide the desired outcome, but also had a large community that shared all kinds of resources. Building the search mechanism was a matter of connecting a small number of free snippets of code provided by the community.

Lessons Learned: Today, with the consolidation of many open-source big data tools, handling unstructured data can be quite straightforward. Even with little previous knowledge about the topic, it is possible to quickly set up an environment that allows one to evaluate whether the chosen tool can handle the job.

However, there are some limitations that need to be addressed. For example, it is interesting to note that any study, such ours, has limitations. In particular, our study examines the implementation of lean production in knowledge work, investigating the creation of an MVP to look for data in an unstructured big data. It is possible that our observations do not generalize to other laboratories. In addition, while MVP intermediate results are promising, a final implementation is still ongoing work. Finally, the question arises as to whether the innovation lab is really doing "lean" production. However, our study is not based on the epistemological concern of whether the approach we are using is really lean. Because no definition of "lean" in software is fully accepted, we relied on the fact that the lab was consciously trying to create a lean system for software services. The ideas proposed in the innovation lab were inspired by lean thinking anyway, so that we can learn from the development attempt.

Implementing lean innovation in an organization is more than just using the right methods and tools. To implement lean innovation successfully, rethinking is needed. It is necessary to foster a culture that identifies the needs of change and is prepared to deal with constant change. Systematic methods to bring value to companies cannot be deployed at one go. To implement long-term lean innovation, participants need to be involved and accustomed to a process of continuous improvement. Change processes often fail due to lack of employee involvement, even if the measures are obviously reasonable [12]. Therefore, the implementation of lean innovation in general must be adjusted to the specific conditions of the company.

9. Conclusion and Future Work

In this research, we presented a development process of unstructured data processing MVPs with big data tools in an innovation lab. We believe that our ongoing research is beneficial in that it can help practitioners and researchers who want to understand and improve their knowledge about lean products, and how to build MVPs and open-source innovation labs.

The analysis of the data generated by user interactions, along with the survey, confirmed the MVP hypothesis. We were able to confirm that a finished version of the product will provide great value to the suppliers. The team believes that the process followed to raise and prioritize the requirements was a major contributor to this result. Another key result was that the chosen open-source and big data tools guaranteed the product technical viability.

Provided with these validations, the e-Procurement Company board of directors decided to invest in this solution. This movement can be translated as moving the initiative to the Transfer phase of Gartner's framework. In this phase, an agile development team is responsible for developing production ready-versions to be released in the market.

As future work, we will develop other MVPs, and as a result, it will be possible to understand and improve the innovation lab process. In addition, our analysis suggests that more effort needs to be invested into empirically evaluating the existing approaches, and that there is an avenue for future research in the direction of mitigating the identified limitations.

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