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Pereira Problem Solving: Business Research Methodology to Explore Open Innovation

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Abstract: Problem solving skills are increasingly important to be able to tackle the complex problems encountered in the business world. Nowadays is increasingly important to achieve sustainable development, focusing not only on economic profit but also on creating social value. It is widely agreed that the principles of scientific management can lead to more effective solutions for complex problems. Problems have to be looked at objectively, with methodology and intellectual integrity and modesty. Several techniques have been developed to help analyze the causes of the problem or formulate solutions. Although these business research techniques are important tools, they are presented as isolated measures. Pereira Problem Solving methodology presented provides guide to address business and management problems. It is an integrative and easy-to-use instrument that helps organizations adopt scientific management practices and will enhance the efficiency of the solutions encountered.

Keywords: problem solving; problem formulation; scientific management; solution formulation; business research techniques

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1. Introduction

The management world is increasingly guided by the creation of a common purpose, in a mostly liberal context of serving the ecosystem's stakeholders and conducting unique experiences while creating economic and social value, measuring this same achievement through objectives, goals and performance. However, the life cycle of organizations has never been so short, in accordance with the VUCA (Volatile, Uncertain, Complex, and Ambiguous) context. So the permanent transformation of the business model and supply is a mandatory principle and pillar of survival, driving the organizations into a permanent state of mutation, which has recently been emphasized by the pandemic. This transformation is not limited to organizations and business models, as the labor market is also permanently adapting [1]. More than ever, it is extremely important to ensure the sustainable development of organizations, adding not only economic but also environmental and social value [2].

Complex problem solving is one of the main competences needed to maintain successful businesses. Chen and Hitt [3] point out the gap between problems taught at management schools and those found in real world. It is increasingly important that problem solving abilities are taught in order to address the complex problems faced in the business world. Furthermore, the approach used should be based on facts, and executed in an objective and reproducible way to avoid biases [4].

Based on the existing work on problem solving and available methods to formulate solutions, the goal of this paper was to propose a framework to address problem solving in business research. Scientific management has a very wide scope which makes it hard to apply to concrete problems; on the other hand, the techniques, formulas and models that support it are very specific and usually presented without any connection. The proposed framework will solve this "middle-level" approach, contextualizing the scientific method and all the business research tools providing the contemporary that has to make robust decisions in a short time. Furthermore, the proposed model provides a framework that integrates the contribution of other organizations and professionals for problem solving, a key element of open innovation [5]. Open innovation scholars have focused on the need for focal organizations to transcend their boundaries by sourcing knowledge and technology externally. As argued by Felin and Zenger [6] organizations need "to transcend their boundaries by sourcing knowledge and technology externally" (p. 916) since the extension of the problem-solving process to external knowledge sources leads to financial performance and innovation [7,8]. The implications of this approach is also applicable on non-profit organizations [9,10].

The paper is structured as follows. The next chapter describes the context of problem solving, justifying the need for a more conceptual model and competences that should be developed. Afterwards there is a description of the methodology used. The information gathered is divided in two chapters: Problem formulation, which focus on the definition of the problem, and Solution formulation, concentrated on the techniques that can be used to formulate an appropriate solution. The model proposed is presented in the Case Study and its main contributions are shown in the conclusion.

2. Theoretical Background

Problem-solving theory incorporates a set of steps towards identifying solutions to specific problems and achieving organizational objectives, along the so-called problem-solving cycle [11]. This cycle starts with the recognition of the problem and the analysis of its causes and ends with the monitoring and acquisition of knowledge for future situations and the strategy to solve it. In practice, being a cycle, it cannot be said that it ends in the assessment phase, which should be understood as the beginning of a new problem-solving cycle [11].

Intuition is an essential tool and one of the important characteristics of the problem solver and, depending on the experience of the decision maker, may lead to very quick, accurate, and appropriate decisions [12,13]. However, in a highly complex and competitive context such as today's, it is not only fundamental to complement this approach with analytical problem solving processes [14], but it is also essential that this characteristic is complemented by others as described below.

According to the World Economic Forum [1] the expectation is that in the next five years there will be a substantive change in the core skills valued in the labor market. The pandemic context has greatly accelerated industry 4.0 where business models have strengthened their technological choice, supply chains have been restructured, education and academia have reinvented themselves in form and scope, mobility and tourism have been forced to diversify their offer and in general all businesses have had a direct or collateral impact emphasizing that the only way for a business to survive is to adapt continuously to change or provoke it from within.

The WEF [1] contextualizes the future of management and its main function will be based on the principle of "serving the other" in an internal and external perspective to the organization, both in terms of the development of human capital (internal), as well as the resolution of economic and social problems (external). It is within this spirit that the manager of the future resembles a "coach" with above-average emotional intelligence and a unique ability to solve problems and make it happen through others. Thus, a set of key competencies are established by the WEF [1] as essential to manage a business or company successfully:

- Interpersonal skills: management positions are about people so the skill to build successful relationships is fundamental. To lead a team, it is necessary to earn the respect of all stakeholders. To achieve this, it is necessary to know how to effectively deal with different people.
- Communication and Motivation: effective leaders must master all forms of communication, including written, verbal, and listening skills. A manager will deal with a huge variety of people, from different religions, cultures, motivations, convictions and spend more than 90% of the time communicating, persuading, motivating, and negotiating. Recognizing distinct organizational cultures and mastering the communication tool is thus critical to business management and administration [10].
- Organization and Delegation: a manager handles several responsibilities, people, and objectives simultaneously. Personal organization is of utmost relevance. Sloppy work practices, delays, and a general lack of organization will not be tolerated at this level and will set a bad example for employees. Effective organizational skills reduce stress, save time and ensure important deadlines are met. Delegation capacity is thus key to getting results through the team at the same time as educating employees. It is therefore essential to know how to identify the skills of all team players and assign roles to each, depending on their set of technical and personal skills. Delegating is not a sign of weakness but can, in fact, multiply the amount of work a manager can do—while developing team trust and skills.
- Strategic Thinking and Planning: it is the manager's job to think about the general panorama of the entity he manages; therefore, besides focusing on immediate tasks and responsibilities, it is essential to project the future. Furthermore, the skills are also reinforced by the manager previous experience in problem solving, enhancing the concept of learning by doing [12] that provide ways of organizing information to be used as a reference in future situations [13]. This contributes to better defining priorities in line with the company's objectives, reviewing systems and policies, participating in the training and development of its team. As a strategic thinker, the manager will encourage innovation and change to make the team and the organization more productive and achieve better results.
- Problem Solving and Decision Making: non-conforming with the status-quo of the organization in general is a continuous and daily function of a manager. Along with the task of detecting and solving problems. This mission requires exceptional attention to detail and the ability to remain resilient in continuous improvement. Creative thinking will help to find innovative solutions that minimize the impact on teams and on the business as a whole. Knowing how to reflect and analyze after collecting evidence and opinions from various sources is very relevant when more structuring decisions need to be made. Being able to quickly weigh the pros and cons of a situation and make an informed decision is essential to the success of the organization.
- Business Skills: to deeply understand the business where a company is inserted, to know the value and supply chain, as well as its fragilities, to dialogue with clients and to know their perspectives, expectations, complaints and abandonment which represents a key issue for problem solving in open innovation context [15,16]. This allows the manager to have more control and dominion of the business where it is inserted. No one can truly lead a company if they do not develop this deep and at the same time comprehensive dominance capacity, which is a mandatory premise in decision making processes.
- Mentoring and Coaching: in addition to the business-focused decision-making exercise, managers need to play a supportive and supporting role in team development. When a manager leads an organization or a team he must put his knowledge and skills at their disposal and share with others what he has gained from his past repertoire of experience. Thus, a manager must train and advise his employees to develop self-confidence and skills. In a top position of an organization, this gesture is the driving force behind the progression of the team.

In short, the 10 main competencies needed for effective management are organized in four macro-trends, namely, "problem solving", "personal management", "working with others", and "development and technological use". These competencies focus not only on economic value, by producing newer and better products or services, but also on social value, by developing skills and interpersonal relationships.

It is not new that sustainable development means more than increasing profits, it also has to include a responsible management of natural resources and produce symbiotic relationships between all stakeholders, as presented by the Triple-Bottom-Line (TBL) agenda [2]. The value of sustainable human resources management has already been showed, it leads to more satisfied employees which not only reduces employee turnover, reducing organizational costs, but also enhances performance, increasing profits [5,17]. Future managers need to develop a comprehensive set of skills in order to promote sustainable growth to their organizations.

3. Materials and Methods

Solving complex problems entails different steps; only after the problem is thoroughly described and analyzed can causes and respective solutions be searched for. Therefore, this research was divided into three main topics: problem solving, business research methods and statistical methods. The results were divided in two topics, problem formulation and solution formulation. The first describes different approaches emphasizing the importance of scientific management principles. The second includes the most used techniques to analyze the problem and then propose solutions for it. After all the information is collected, a new framework is proposed that comprises all the needed steps to effectively evaluate the problem and study possible ways of action (Figure 1). The conceptual model recommended is illustrated with a representative case study developed for retail in 2019.

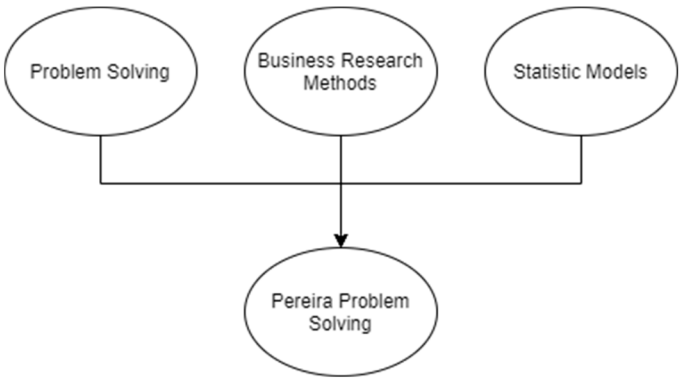

Figure 1. Methodology scheme (authors).

4. Problem Solving

The idea of scientific management comes from the principles of science and the scientific method and provides a fertile ground for cross-discipline and out-of-the-box thinking, as key ingredients for open innovation [18]. To manage work in a scientific way, it is necessary to understand it, analyze it and apply scientific methods and techniques. The "Rule of Thumb" method means that the manager makes decisions solely based on his past experience. This approach is untested and unscientific, so a successful outcome is not guaranteed [19]. Taylor's [4] principle states that it is necessary to think, analyze, and test, before deciding and thus avoid a "trial–error" methodology which is neither efficient nor effective. Taylor insists that management must be based on a cause-effect analysis and study of the relationship between variables, so the decision becomes scientific, with standardized processes, more predictable and transparent results, and efficiency and effectiveness of resources.

4.1. Stages of Management Maturity

Management must be an exercise of strong intellectual honesty, guided by rigor, method and based on science, not a game of excellence in which one decides first and then tries to obtain justifications with bias or assumptions not thoroughly verified, leading to corruption or harmful management [19]—Figure 2.

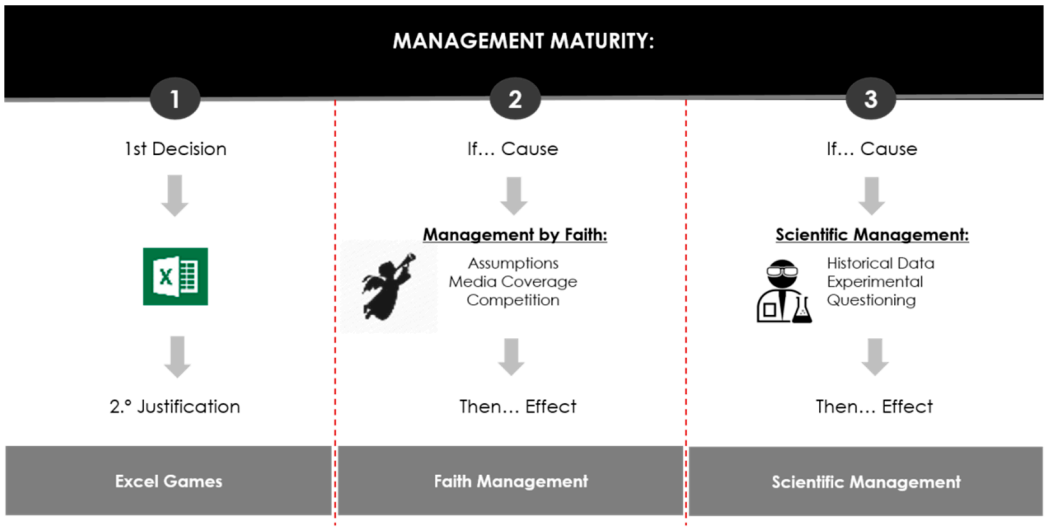

Figure 2. Management Maturity Stages (authors).

Sometimes a situation may occur in which emotion or incompetence causes the manager to act and make decisions based on his personal experience or common sense, sometimes forced by the context or by the force of competition, resulting in a management based on faith and belief and not on science.

New management, particularly that based on data, facts and the power of technology or experience is close to the principle of scientific management advocated by Taylor [4] and currently described by Jensen [20], in which data, experimental method and collective intelligence are powerful instruments to promote science in particular in management and administration [4].

4.2. From "Acts of Faith" to Scientific Method

Between personal opinion and science there is a long distance, but to practice scientific management it is not exactly necessary to have a laboratory, to possess all data or inquire the whole population. The principles of intellectual humility, intellectual honesty, curiosity, openness of mind, are guaranteed symptoms and behaviors that bring us closer to science and a more rigorous management.

Management based on "acts of faith" is characterized as a set of behaviors or excuses, inappropriate for decision making in particular in the context of problem solving and manager behavior in general. In turn, management based on science principles [20], in particular with regard to decision making, is characterized by a different set of behaviors, both illustrated by Figure 3.

Problem solving is a systematic, organized, and focused process [21] that is established in three main moments: the past, the present, and the future. The entire analysis exercise must begin with a deep and rigorous appreciation of the problem to ensure that it is perfectly understood, defined, situated, objectified, being based on facts, or on contexts close to reality (Figure 4).

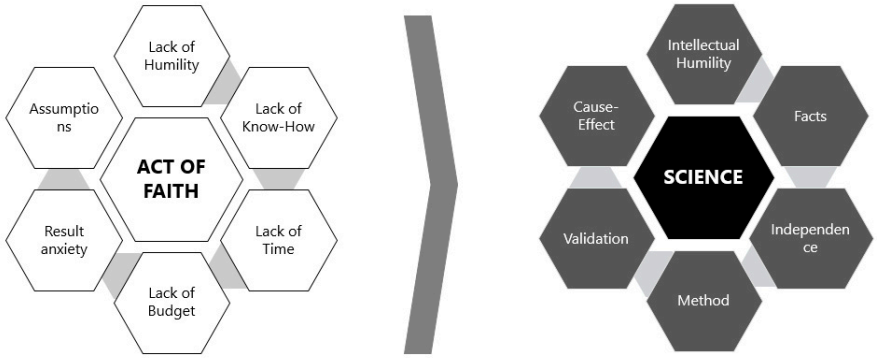

Figure 3. From "Acts of Faith" to Scientific Method (authors).

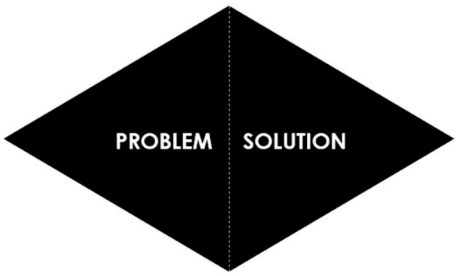

Figure 4. Problem-Solving Exercise Formulation Scheme (authors).

The level of detail, depth, resources and time of the analysis depend on its complexity and criticality. Not investing time in the analysis of the problem is one of the main causes of management failure [22].

Once the exercise of responsible understanding of the problem has been completed, the proposed solution can be defined. Above all, the solution has to respond to the main causes that originated the problem and then to counteract them. If the causes are interdependent the solution may be unique; if the causes are independent, the formulation of a solution for each cause may have to be considered. The solution proposal is typically a faster exercise than the diagnosis of the problem, which when done with quality, allows the preparation of the solution to be a more administrative act [23].

4.3. Cognitive Bias

One of the main issues of the problem solving exercise is the cognitive-bias described by Bhardwai et al. [24]. This is one of the main factors that hinder the rigorous formulation of solutions, when the principles of science and scientific method are inhibited. These occur mainly due to conflict of interests, emotional aspects, lack of time, lack of empathy, lack of training/education, among others [25].

In problem solving the cognitive-bias typically forces two main phenomena: the first is to give more importance (time) to the discussion of the solution than to the analysis of the problem, and second typically when discussing the problem, the focus is more emotional than rational, seeking to find the responsible and personalizing the exercise [24]—Figure 5.

The main recommendation is to invest time in the analysis of the problem and not in the analysis of the solution [9] allowing effective and efficient decisions.

An element to highlight in the cognitive-bias phenomenon is the emotional distortion that a problem-solving exercise can have whenever the decision-maker is in conflict regarding the impartiality or impartiality of the analysis, particularly when the decision may bring personal benefit to himself [25]. In summary, it can be said that emotion distorts rationality and does not allow to see more objectively [25]—Figure 6.

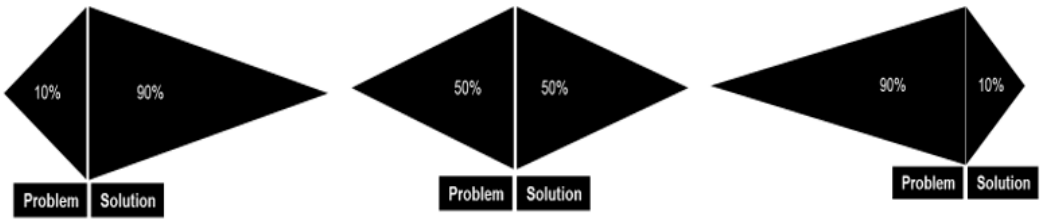

Figure 5. Cognitive Bias in the Exercise of Problem Solving (authors).

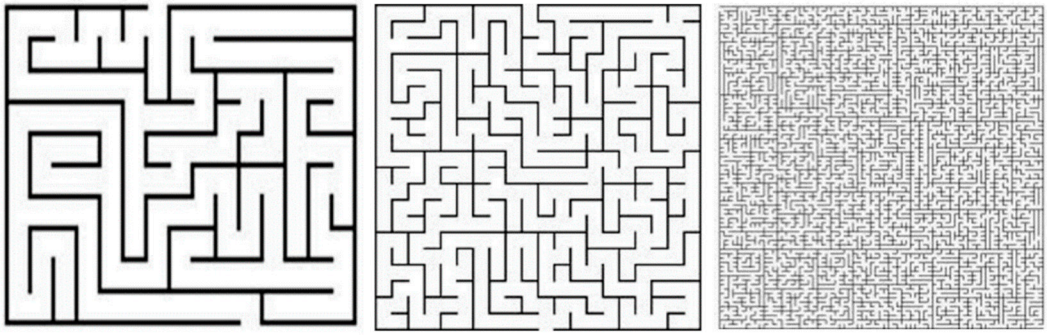

Figure 6. Illustrative example of Cognitive-Bias in Problem Solving (authors).

4.4. Problem Solving Process

The problem solving process thus follows the principles of scientific management when applied to management. It is based on facts, in a rigorous methodical process in which two different people may reach close conclusions [26].

According to Pereira and Santos [22], the process begins with defining the problem. It is recommended that the problem is concrete and specific and isolated so it is easier to solve. It must be written down so that it is presented in a clear way.

Then begins one of the most important exercises in the process which is the search for causes, based on facts, in particular diverse sources, which will allow connecting points, finding perspectives, in a permanent question-hearing binomial, which can be more formal or informal, more structured or less, more qualitative or quantitative, depending on circumstances and context.

After collect the causes, which can be based on a sample of convenience, a sample by saturation or another that identifies itself appropriately, it is important to establish the vision of the whole in a summary way, answering the question, why this problem happens, and ensuring that the information makes sense thus contributing assertively to the understanding of the problem.

Once this stage is finished, one enters the second moment where a solution is proposed. This stage begins with exercises to break the problem into sub-problems, or to analyze it in various ways, as long as its formulation has not isolated or instantiated it adequately. To walk through the problem (before, after, detail, and all) helps to elevate the intellectual domain on it.

After identifying the causes, the process of proposing solutions begins, in particular by basing the proposals on the causes, and denying them, countering them, mitigating them, transferring them or accepting them. Each strategy results in a simple or multiple action plan, depending on whether the causes are interdependent or independent.

However, it should also be noted that not all solutions may be feasible from the point of view of resources or time required, as well as effectiveness. Therefore, it is necessary to consider the pros and cons of each solution so that it fits the requirements or restrictions of the organizational or personal context of the manager.

After deciding which solution or solutions to implement it is essential to establish an effective action plan (what, who, and when) in order to make it happen. Not less important is to check, after an adequate period of time (it depends on the type of problem and the type of solution) if the solution has worked or not (Figure 7).

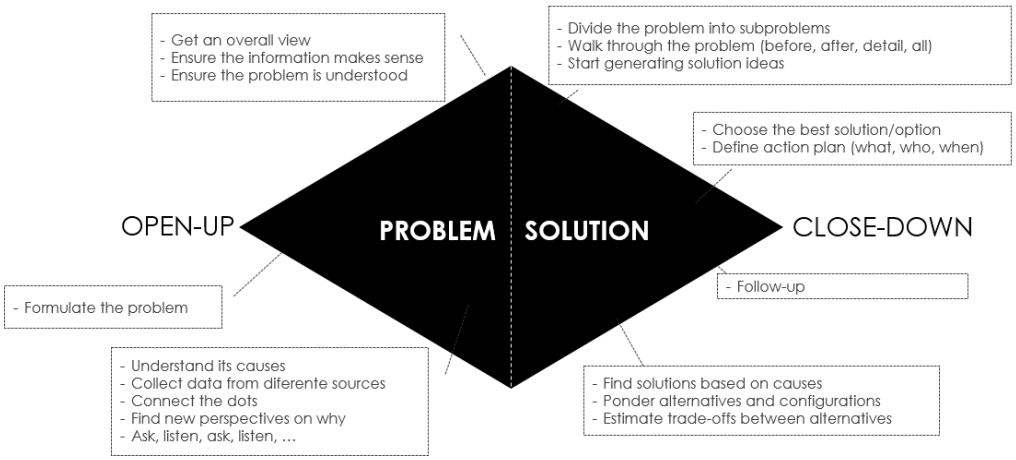

Figure 7. Workflow of the Problem Solving Process (authors).

In summary, the exercise of solving complex problems in a working process can also be illustrated by Figure 8 below.

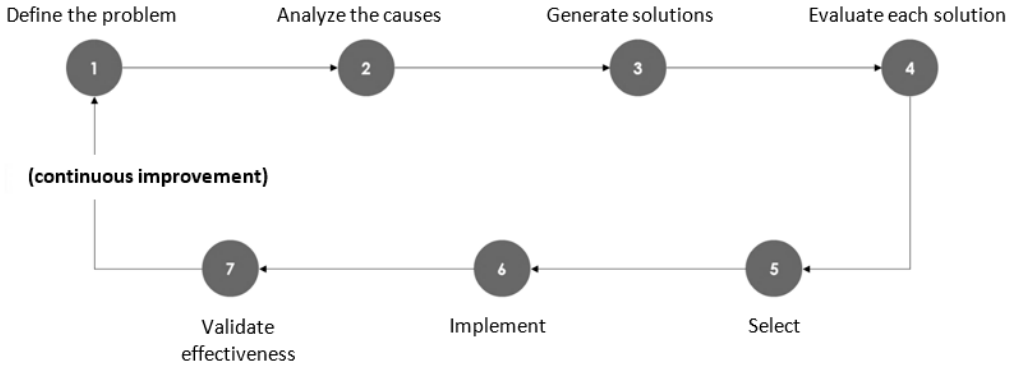

Figure 8. Problem solving process as Workflow (authors).

5. Solution Formulation

The formulation of the solution focuses substantively on the analysis of causes [23]. With the causes rigorously identified, the solution is easier to work with. There are multiple techniques available to analyze the causes, most of them originated in the area of quality management and statistics. The formulation of the solution can be organized in three main steps: analysis of causes, analysis of statistical (in)dependence on causes, and strategy of response to causes.

5.1. Analysis of Causes

5.1.1. Ishikawa Technique

One of the best known techniques is the technique of Ishikawa [27], also known as fishbone technique, which represents the problem in the "head of the fish" and in the spine of the fish in a tidy and organized way the causes that can have a simple primitive, or be arranged in cluster, and generate the principle of the causes of the causes, approaching the root cause.

This technique starts by identifying the problem in detail and all the stakeholders participating. The next step is to find out what are the main factors involved and that may influence the problem. For each of these factors, a cause will be identified in the next stage of the technique; complex causes can be decomposed in smaller ones. Finally, a line of research can be defined to test which are effectively the most likely causes of the problem.

5.1.2. Technique of the Five Whys

The technique of the five whys is the same as the Ishikawa technique of the most used in the area of quality [28] and its main objective is to find the root cause of a problem. This technique is also known as the technique of children who innocently, but for the purpose of connecting dots and building rational, will continually ask "why" about all things in their interaction with older people.

The technique has the goodness of simplicity, and the power of cause to reach the root cause of problems [29] allowing in fact to make assertive and effective decisions. It is typically carried out in a dialogue format that is often informal, but powerful when it comes to the development of a rational. It must be executed in a professional and empathetic manner for it to work [30].

5.1.3. Problem-Breakdown Technique

The technique of splitting the problem has the main objective of isolating the problem and converting it into a more objective and understandable version [10]. One of the main obstacles to problem solving is the size of the problem, or its scope. Turning the problem into an objective, concrete definition facilitates the exercise and removes much cognitive bias [24].

In the case mentioned in Figure 9 we can observe that the problem "Project has a big delay", after all it is materialized in "the supplier is not able to deliver on the established date", which from the point of view of analysis of the causes, removes high complexity to the problem and allows us to focus on what is relevant.

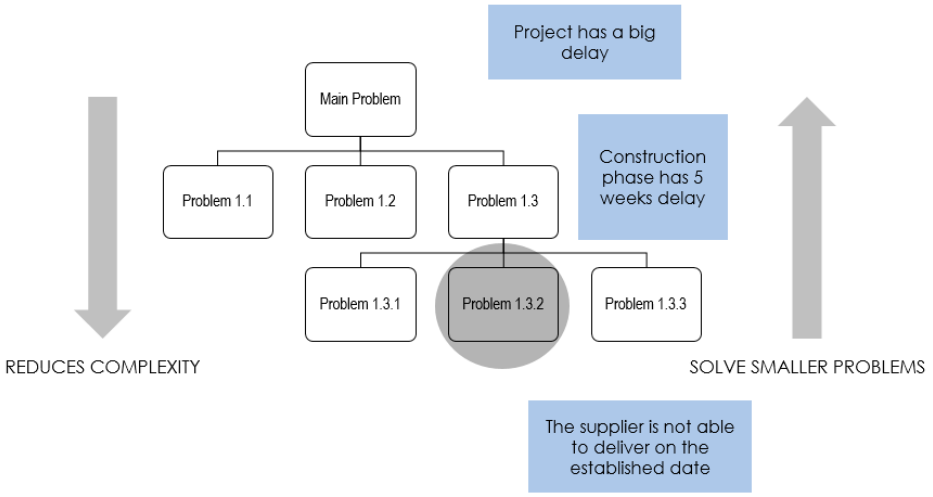

Figure 9. Decomposition Technique of a Problem in Sub-Problems (authors).

5.1.4. Pareto Technique

The technique of Pareto [31] is one of the main phenomena of management, which tells us that 80% of a problem results from 20% of the causes, and thus does not allow us to force the analysis on what is relevant and not what is accessory [32].

Thus, this technique formulates the causes of a given problem in a histogram of decreasing frequencies, thus allowing an enormous assertiveness and greater efficiency in addition to rationalization of resources during the intervention. Sorting the causes in order

of frequency from highest to lowest obtains effectiveness and efficiency by focusing only on the relevant causes.

5.2. Analysis of Statistical (In)dependency

From the point of view of statistical analysis, it is relevant to appreciate the causes and confront them in terms of relationship, in order to understand whether or not they are correlational [33]. In case there is correlation it may become easier to intervene from the point of view of the solution, since there is potential for a solution to solve more than one cause simultaneously [34]. If the causes are unrelated then it is necessary to develop several solutions, at least one for each cause:

5.2.1. Statistical Dependency

In case the correlation is positive (approaching one) the events tend to be mutually inclusive, which may mean that one can be the cause of the other or have the same root cause. If the correlation is negative (approaching -1) events tend to be mutually exclusive, which may mean that the existence of one phenomenon may inhibit the existence of the other.

5.2.2. Statistical Independence

If the events are statistically independent (correlation tending towards zero), then each phenomenon has to be studied independently, and it is unlikely that the same solution will work for both.

5.3. Strategy and Solution Proposals

If the causes of the problem are accurately diagnosed, it is of the utmost importance that the solutions correspond in terms of effectiveness and assertiveness to deny their occurrence and inhibit them. Among the various strategies of responses to the causes originating the problem, four main problems are identified [35]: avoiding/eliminating the problem, its feasibility depends greatly on the context; mitigating the problem, reducing its effects; transferring the problem to entities more capable to deal with it; or accept it and simply be aware of the problem.

5.4. Visualization and Data Collection

The visualization of the collected data that feeds the problem solving process is of extreme importance to make the exercise intelligible and intellectually challenging. According to Brown [36] the qualitative and empirical nature of most management studies, being this above all a science based on people and behaviors, modeling, and visualizing phenomena, assumes an essential importance.

Table 1 summarizes the main data representation techniques. According to Cooper and Schindler [26], the choice of a visualization technique depends above all on the objective of the interpretation, and sometimes a combination of techniques is the best solution for visualization.

Data collection techniques depend on three main characteristics above all: the quantity of data to be collected, the quality of the data to be collected and, last but not least, the speed at which it is intended to be collected, often by deadlines imposed both in terms of market and process [36]. Thus, Table 2 compiles the main "Business Research Methods" techniques that are widely used, ranging from more informal exercises to formal and statistical exercises of large volumes of data, giving rise to the Big Data phenomenon.

The sample needs to be representative and significant so the sampling error is as small as possible within the resources and time available; this is not always possible but it does not mean that no data is collected and that one decides empirically [26]. One of the most convenient approaches in qualitative and more informal research is the saturation sample, not often explored, but of maximum convenience and relevance to increase the intelligence of the complex problem-solving exercise [37].

Table 1. Summary of Data Representation Techniques adapted from [26].

Technique	Goal
Pareto Chart	Focus the study on what is relevant and discard the accessory.
Fishbone	Cause and effect relationships.
5 Why's	Analyze the root cause of a situation.
Flowcharts	Understand the flow of a process between two points.
Tree Diagrams	Decompose a situation into smaller elements successively to focus and isolate situations.
Mind Maps	Organize information in common groups, discover relationships and systematize.
Gap Analysis	Compare longitudinal situations, typically between past and future.
Benchmarking	Compare past performances with futures or in a competitive context.
Scatter Diagrams	Analyze the relationship between two variables, for example for statistical independence validity.
Control Charts	Analyze the evolution of a variable within acceptable parameters.
Trend Analysis	To appreciate the evolution of a situation in a period of time and/or make extrapolations.
Affinity Diagrams	Group information with common elements.
Interrelationship Digraph	Establish relationships between various elements from a flow, causal or impact perspective.

Table 2. Summary of Data Collection Techniques adapted from [26].

Technique	Quantity	Quality	Speed
Interviews	Download	Top	Top
Questionnaires	Top	Average	Average
Note	Average	Average	Top
Focus Group	Average	Top	Top
Telephone Calls	Average	Average	Top
Face-to-Face	Average	Top	Top
Expert Opinion	Download	Top	Average
Benchmarking	Average	Top	Average
Documents	?	?	Top
Databases	?	?	Average

This exercise should always be accompanied by data collection from diverse sources. Diversification is essential to prevent cognitive bias and thus obtain different perspectives on the phenomena in question. Diversification must take into account the quality of the source, in particular the knowledge or mastery of the subject. Not qualifying the source can condition it substantively and jeopardize the results [38].

6. Case Study

The researched performed emphasizes the value of the "Pereira Problem Solving" [9] methodology and it was possible to expand its application with an illustrative example. In line with Mueller [14], the main goal for presenting an illustrative case study is to describe the application of the method in a real situation and to guide the reader and provide a common language about the topic. Furthermore, the use of an illustrative case study allows highlighting the applicability of this framework in a real-life setting, as recommended by Soman, van Donk, and Gaalman [39].

A big electronic retail company had a problem with customers leaving their stores without buying. Once the problem was identified, all the impacts of this problem were described: decrease in sales, elevated costs for the volume of sales and employee turnover. The next step is to analyze the trends of the impacts in order to understand the urgency of the problem; in this case, sales went down 10% when compared to the same period the previous year.

Afterwards, the causes of the problem have to be identified. In order to understand why costumers were leaving without buying 119 costumers were interviewed during 10 days. After gathering all the answers, a Pareto analysis helped identify the main causes of the problem (Figure 10).

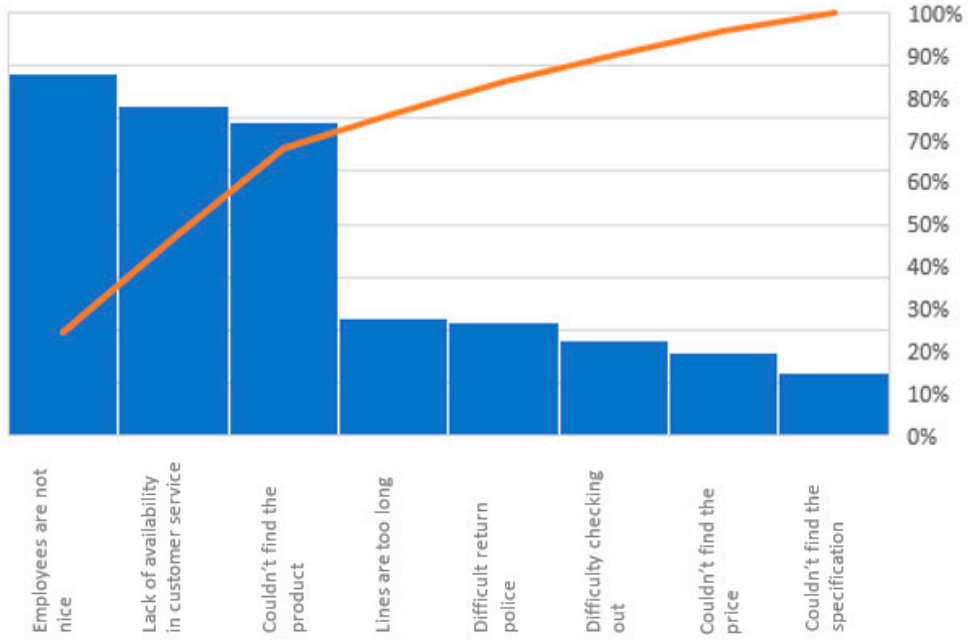

Figure 10. Example of Pareto analysis of Interview results (authors).

Knowing the main roots of the problem, then it is time to start thinking of solutions. The causes must be evaluated in terms of statistical (in)dependence (Figure 11). Solutions must be formulated for the causes in an integrated or independent way, and if there are alternative solutions it is necessary to weigh the pros and cons of each one, and select solution(s) according to the restrictions and resources. The implementation proposal must be accompanied by an implementation plan that instates what, who, how, and when.

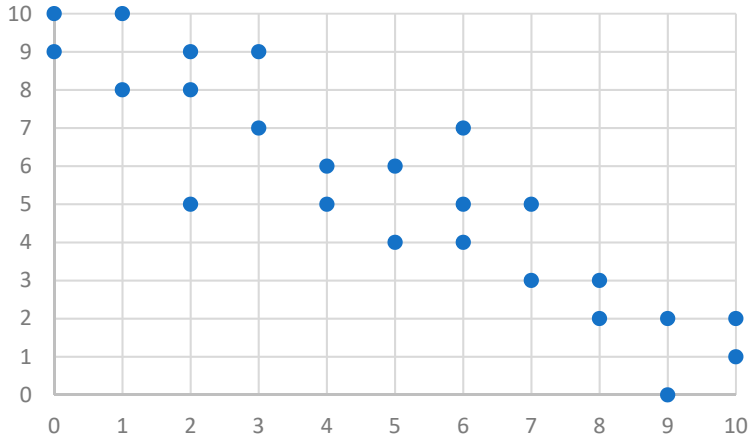

Figure 11. Example of negative correlation between variables (authors).

Having identified possible solutions, the next step is to analyze the benefits of each. The benefits should be exactly the negation, inhibition or reduction of the impacts of the problem, allowing in this way to appreciate the value of the solution.

Figure 12 shows the global analysis of the illustrative problem. This model proved to be able to assist organizations in solving their problems [22]. Although the existing model already follows a scientific approach, it can still be improved. Using Structural Equation Model, in particular, Partial Least Square Path Modeling (PLSPM), it is possible to validate and quantify the relationships previously identified [40]. The causes, impacts, benefits, problem, and solution (latent variables) can be measured by various observed

data, obtaining the maximum of explained variance for each variable. Assuming that the observed data explains the latent variables, then the relationship between them is measured in order to get the size of the effect (small, medium, and large) and the value of the coefficient in a linear regression. Continuing the present case study, Figure 13 shows what a result from the PLS Path model could be. From this it could be seen that although employees not being nice has a stronger effect, the lack of availability has a larger coefficient which would make it the main cause of the problem. Since the causes were correlated it was possible to find one unique solution, which will deliver different benefits.

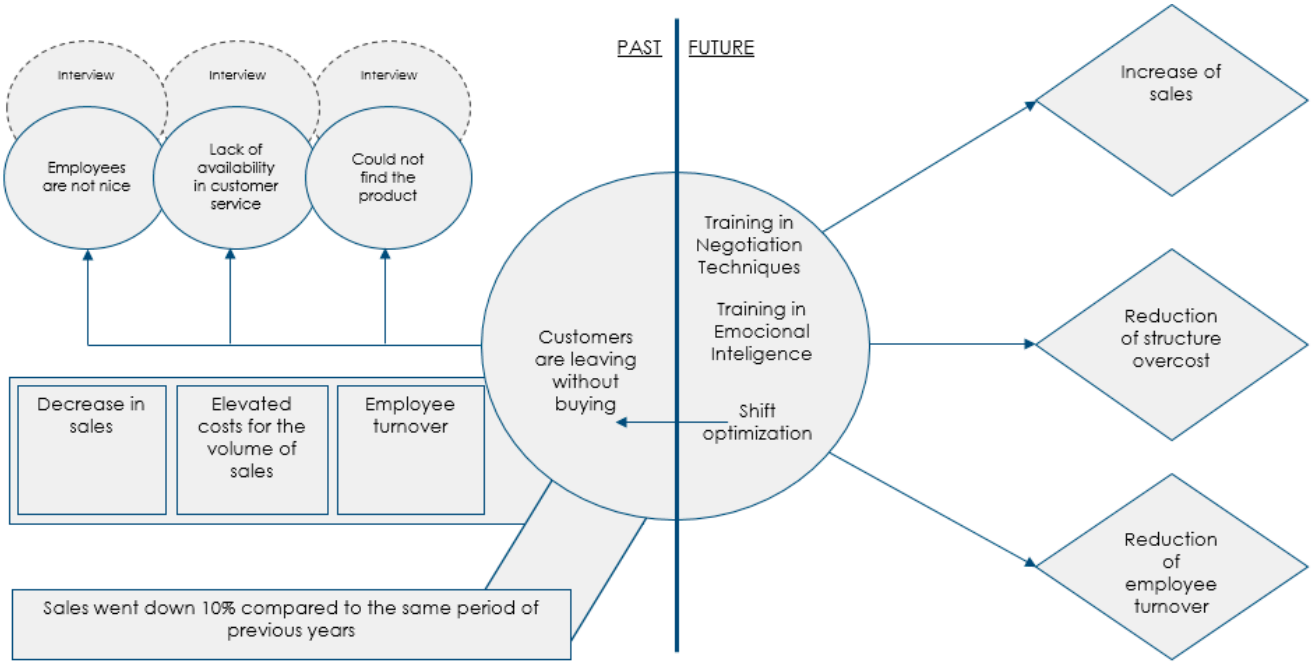

Figure 12. Example of Pereira Problem-Solving Diagram (authors).

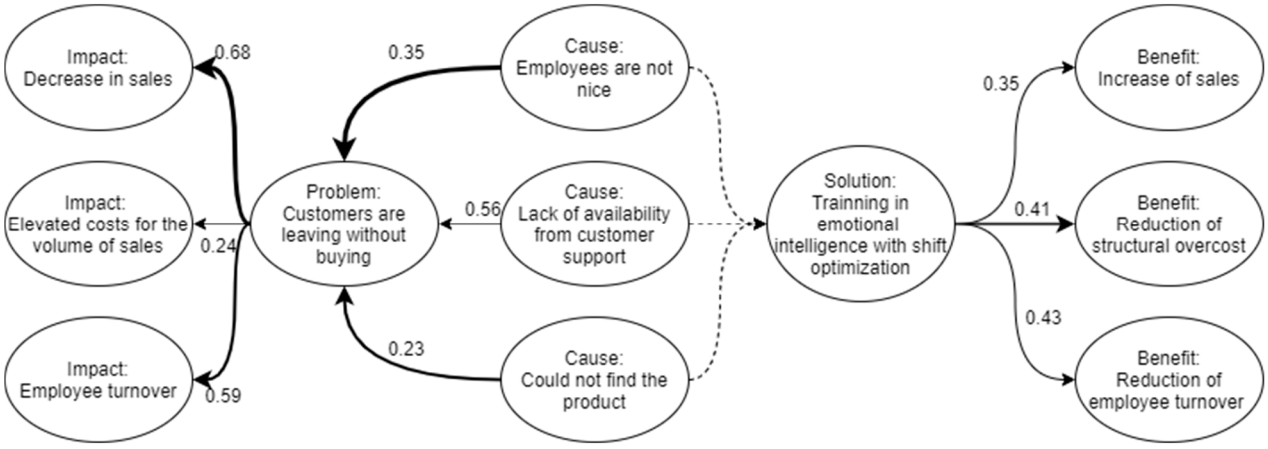

Figure 13. Example of Partial Least Square Path Modeling (PLSPM) results (authors).

The use of a PLSPM allows quantifying the real relationships that were estimated and have a better understanding of the effects of the proposed solutions, which can help allocate resources if choices have to be made. This final step increases the objectivity when looking at the benefits, reducing the over-estimation of the solutions' value.

7. Discussion: Pereira Problem Solving and Open Innovation

Open innovation to be effective requires a collection of tools and techniques to guarantee the quality, accuracy, and velocity to follow the open innovation dynamics. The Pereira Problem Solving methodology gives a set of references for data collection, data analysis to allow problem solvers to leverage collective intelligence to innovate products, services and in the end to solve market problems based on a scientific approach.

Taylor [4] was the first advocate of scientific management. He believed that every problem should be addressed with an impartial perspective and causes should be analyzed through standardized processes to ensure effective solutions. It has since been proved that the scientific approach can lead to better results and make a better use of the available resources [22]. Responsible management of resources and transparency in results are part of TBL agenda in order to achieve more sustainable organizations [5,41]. The development of problem-solving skills will also promote sustainable human resources management which will result in better results for the organization and include the last pillar of TBL—planet, people, and profit.

Nevertheless, Taylor presented only an ideology to follow. This ideology has to be transformed in practical measures that companies can apply to solve theirs and their clients' problems. Taylor's principles have to be taken to the next level and transformed into hands-on procedures.

Most authors agree that problem solving has to be guided by objectivity, method, and intellectual honesty and humility [19,20,26]. As such, it is insufficient to develop innovation internally, and it must be broadly shared throughout the organization, with an across department and inter-organizational approach. This implies the investment of the adequate resources to absorb the new innovation and take it to market [42].

It is also believed that the understanding of the problem and its causes is a critical step and should be done in depth [21,22]. Only after a clear understanding of the problem should the proposition of solutions begin. Furthermore, there are different ways to identify the possible causes of a problem [23,27,28]; however, they need to be validated with facts afterwards.

Despite the statistical tools identified, the authors presenting them fail to present a complete procedure where they can be applied. Cooper [27], while performing an extensive analysis of the available business research methods, defends only that they should be used to implement scientific management processes. Once more these processes are not formalized or detailed in concrete measures or steps to follow. Furthermore, the problem-solver characteristics are also an important variable to consider, special the decision-maker intuition, which complements the analytical approach proposed in the model [43]. As such, the model aligns with previous research related with idea evaluation mechanisms where multi-criteria rating scale are found to outperforms prediction markets in terms accuracy and satisfaction evaluation [44].

The Pereira Problem Solving methodology addresses this gap, providing a complete and detail script that can be tailored to each problem and context. Its application can improve the quality of the solutions proposed for different business problems. The model also contemplates the participation of third parties, enriching the solutions through collective intelligence, as suggested by Chesbrough [42]. Moreover, the model can be complemented with other processes associated with open innovation, such as crowdsourcing which can be implemented in the form of an open call [45,46]. Accordingly, the combination of crowdsourcing with open innovation allows the participation of several stakeholders, professionals and "crowds" of amateurs to solve problems and promote innovative [42]. The organizational culture is an important topic to consider when applying the Pereira Problem Solving. As recognized by Yun et al. [47] the appropriate culture for open innovation is the combination of several types of entrepreneurship (Entrepreneurship of novice entrepreneurs, intrapreneurship of employees of an existing firm, and organizational entrepreneurship).

8. Limitations

The present case study is only a first test to the complete framework proposed, there is a need for further testing with other case studies. Furthermore, the guidelines were thought for organizational problems of management in business context. The framework could be applied to other areas, such as social or economic problems but this application was not tested yet.

9. Conclusions

In the present paper the essential of solving complex problems was reviewed. In particular, this competence was framed as one of the most important for the next decade. It was also noted how important it is that learning is translated in behavior changes to create positive and relevant impact.

A framework was then made of the decision-making processes in management, in particular with regard to responsible and science-based management, in which the decision is based on facts and methodologies which, while on the one hand allow rigor, on the other hand avoid the cognitive bias.

As a third relevant element of the paper, the techniques of analysis of the causes of the problem, their statistical dependence, techniques of representation, and data collection, as well as aspects on the sample and sources were deepened.

Finally, a consolidated problem-solving methodology was presented by developing an existing one. The conceptual model was illustrated with a representative example, which emphasizes the application of the techniques reviewed and the model itself.

10. Future Lines of Research

The present work produced a framework to approach business problems with a scientific methodology. These will aid while addressing future problems with a clear and objective view. Nevertheless, the model presented needs to be further tested. Consequently, there is a need for future research to validate the proposed framework in real life problems within different contexts. The model was designed for management or business problems, and an intensive application in these contexts should be done in order to obtain a non-biased validation. The model should be also tested in a different set of contexts, such as economic, social, and environmental or others, to unveil possible sub-configurations and tuning for each different condition.

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