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SUMARIO • SUMMARY • RESUMO

Editorial

In continuation of the joint effort of our group of expert collaborators, we present this new issue of the Project Design & Management journal with the aim of consolidating it as a means of integral and collaborative expression capable of disseminating scientific work for all researchers at an international level. It is an undoubtedly ambitious project that highlights innovation in the management of new knowledge for the design of large quality projects. For all of us who have collaborated in the journal, it is of the utmost importance to present the different topics addressed in this issue, from the planning and management of projects to the methodologies applied to evaluate them, including management models and security in communication technology companies. Thus, how the first article discusses the knowledge about the basic structure of project methodologies to achieve a categorization that identifies their complementarity and interrelation. The paper's results determine that the methodologies of professional associations are much more complex and complete in the processes and instruments proposed for the implementation phases and that an interaction between them will allow us to identify their virtues and potentialities to achieve a comprehensive and superior professional practice.

The second article, on the other hand, proposes the design of a methodology for the development of optimal welding processes for specific thermoplastic materials, using the high frequency welding system. The results reveal that the methodology enables us to obtain the operational parameters of the thermoplastic welding process in a controlled, reliable, and predictable manner through a process in the production of quality products to remain competitive in a growing global market.

In keeping with the line of design, the third article presents a research aimed at creating a methodology for the development of a management model as a basic component in the preparation and evaluation of projects within the scope of the National Investment System of Chile. The results from the paper show that the evaluated methodologies do not take into consideration a module of information about the organization and presented in the operation, thus establishing the importance and usefulness of having an ex ante model for its implementation and ex post operation. In this way, by defining the contents, a methodology was obtained for the development of a model that allows the planning, monitoring and evaluation of an investment project.

The methodology used in the fourth article, corresponds to the analysis of the parameters that the PMBOK and the Value in Construction Analysis employ to improve and optimize the execution of projects. Being the PMBOK, it determines the standards that professionals must have when leading constructive projects, while the methodology of Value Analysis in Construction promotes improvement to materials and processes to create substantial savings and maintain optimal levels of quality. The results of the study reveal that the Value Analysis in Construction is a tool that should be applied by the PMBOK to optimize costs and times in the execution of projects, improving the processes that the PMBOK itself applies.

In the fifth article, the importance of proposing security measures to protect information in corporate IT companies is addressed. Through a bibliographic description and the proposal of a set of security measure suggestions for these companies, the proposed preventive, detection, and corrective measures must be involved in a security and contingency plan disseminated throughout the organization.

Lastly, the topic addressed in the last article of this issue refers to the lack of information on the applicability of standards or models for managing ICT services in Brazil. By implementing a survey on these management models practiced in private schools in the city of São Paulo, it was possible to understand the relationship between the supply of equipment, wireless networks and technological support services as understood to be of quality for the pedagogical professional in schools.

We cannot conclude this editorial without first thanking the Iberoamerican University Foundation (FUNIBER) and the Universities that have collaborated with the entire team of collaborators, both IT and technicians, for this new issue to be carried out under the vision of achieving international recognition.

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COMPLEMENTARITY AND ARTICULATION OF PLANNING AND PROJECT MANAGEMENT'S METHODOLOGIES

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Abstract. Introduction: The objective of this research is to know the basic structures that contain project's methodologies and get a categorization that allows us to analyze the complementarity and articulation of them. Methodology: Starting from the identification of the main project methodologies, categorizations were recognized according to the organizations that promote them; then, the most representative of each type was selected and a comparison was made between the life cycles and the basic processes of each phase within the identified group; Thereupon, synthesis tables were developed that represent each group of methodologies and reflect the common content of each phase; Finally, tables were developed to show the contents in terms of processes, components and instruments. This process allowed a comparison at the group level of methodologies, which allowed to access to conclusions on the possibilities of complementarity and articulation. Results: the comparative analysis revealed that the group of methodologies associated with the International Cooperation Agencies have some preliminary instances not present in the methodologies proposed by the professional associations; On the other hand, it was possible to determine that the methodologies of the professional associations are much more complex and complete in the processes and instruments proposed for the implementation phases. Discussion: The methodologies are complementary in many aspects, an articulation between them will allow the professionals who develop in the discipline to capitalize on the virtues and potentialities of the methodologies that are not their own, favoring an integral and superior professional practice.

Keywords: Project, methodology, planning, management.

Introduction

Studies oriented towards the analysis of projects and the establishment of methodologies, standards and guidelines aimed at increasing the probability of success in them have become increasingly relevant in recent decades. Theoretical contributions and various experiences have generated various approaches in the formulation and management of projects. Consequently, different authors, professional organizations, and academic institutions, focused on the field of projects, standardized styles of design, formulation, management, and direction, creating a framework that has established

multiple trends in the aforementioned topics. However, among the different approaches there are great points of contact supported by the experience and documentation of projects, and in the theoretical development of an activity that has emerged as a discipline in itself.

The organizations have understood that the success in the implementation of strategic changes is based on the formulation and management of projects and that on the effectiveness and efficiency in that aspect depends not only the success in the adoption of measures aimed at the fulfillment of the goals of the organizational structure, but also primacy over an increasingly competitive environment, in which projects infiltrate the entire hierarchical structure of the institution and in all processes: successful organizations not only seek to achieve the objectives of the projects, but also continuous improvement and the development of suitable human resources for each of its functions.

There is a complex universe of project methodologies, including those proposed by international organizations, cooperation agencies, professional associations, educational entities, and even by certain authors who have dedicated themselves to their development.

From the points of coincidence and dissent, the possibilities of complementation and articulation of these methodologies are analyzed to propose a series of recommendations tending, in principle, to identify the one that is most suitable or most appropriate for a particular type of project, or to be able to integrate or articulate them, using the aspects that make them more robust or flexible, depending on the needs of the designer.

Different methodologies from different types of organization were analyzed with the intention of achieving a representative sample of the great variety of styles and methods. The specific selection criteria is detailed in the Method section. In all the methodologies analyzed, it was possible to recognize a definition of sequential steps organized in practical activities and the use of support instruments to structure and organize operations. This study aims to reveal comparatively what dedication methodologies provide to each of the phases and what quantity and complexity of instruments and processes it proposes.

Projects

A project, unlike daily work activities, are unique tasks that are carried out to obtain something that does not currently exist, and may be a product or a service. If we seek to obtain a product or a service, it is because we want to solve a problem, attend to a need or take advantage of an opportunity.

Another important feature of projects is that they are tailor-made, and therefore no two projects are identical, simply because no two circumstances are the same. They may have been similar, but not identical. If we want to intervene on reality, we have to do it considering its particularities and complexity.

From this, another characteristic of the projects emerges and that is that, since they constitute complex interventions, we need to plan or program the actions, that is, the way in which we are going to intervene.

Projects also differ from ongoing operations by having time limits, the project is designed, applied or executed and then closed, leaving a system running, but the project operation ends. In other words, the running system is no longer a project.

The International Project Management Association (IMPA), understands the project as: *"an operation in which human, financial and material resources are organized in a novel way, to carry out a set of tasks, according to a defined specification, with cost and term, following a standard life cycle, to obtain beneficial changes, defined by quantitative and qualitative objectives"* (Reyes and Martínez, 2013, p.21).

Methodologies

Initial research on the best known, used and disseminated project methodologies, allowed recognizing three large groups of easily distinguishable organizations, distinguishing:

- International Cooperation Agencies (ICA)
- Professional Project Associations (APP)
- Eastern academic institutions

This work took into consideration for the analysis and comparison of the phases of the life cycle of the projects: their elements, processes and constituent instruments.

As a basic premise, it is recognized for the life cycle that involves every project, a structure common to all methods, the result of a division into phases. Despite the fact that the characteristics and nomenclature of these phases vary according to the methodology it systematizes, in all of them the idea that a phase of Planning, design or formulation precedes a phase of execution, management, direction or implementation.

Planning Processes

The planning, formulation or design of projects is a complex instance that ranges from recognizing the problem, need or conflict to be resolved; or the definition of requirements established by a principal (organization or private client) until the development of a solution proposal that contains the main aspects necessary to evaluate and submit the suitability or infeasibility of such proposal.

What is formulated in the planning or design instances, is often called a preliminary project. During the formulation, design or planning, there is no materialization, there is no construction, nothing is yet assembled, but it is defined how those later phases will be carried out, it is specified how the project will materialize or how it will be mounted when the implementation phases begin.

Project design involves a process that moves from the general to the specific and in the course of that process the designer must walk a path that begins with the definition of a problem or a need and culminates in the definition of a specific solution, the analysis of the environment and the establishment of the guidelines that will guide it towards the materialization of the deliverable.

Management Processes

Once defined what to do, how to do it, where to do it, when, with whom, with what resources and to obtain what results, all elements specified (or sometimes estimated) in the phases mentioned above, the project execution process begins, which will involve management, direction, administration, assembly, construction activities, that is, the previously planned begins to be carried out.

Regarding the way of naming this or these phases, there is no established agreement, there are those who recognize it as the management, direction, execution or

implementation phase, and sometimes it is even used in combination, for example: management and direction.

This situation is not repeated in the Anglo-Saxon language, since the term "project management" synthesizes these necessary processes to be carried out in the execution phase. Martínez (2016) states that there is no single way to mention the functions of project management, because the powers used to describe such a function are complementary: whoever is dedicated to the implementation or execution of projects is administering resources, directing people and managing processes.

Method

Design

This study is focused on the analysis of the contents of the various methodologies on projects, taking as object of study the bodies of knowledge of different organizations, interpreting the life cycles, the processes that make up each of the phases of the cycle and the processes and instruments proposed for each instance.

A selection of methodologies was made according to importance and dissemination; choosing those that have been most used in their fields of application or that have set trends at a particular time.

From the analysis of the universe of methodologies and the organizations that promote them, it was possible to recognize three large groups that are easily distinguishable: one linked to the International Development Cooperation Agencies; another to the Professional Project Institutions or Associations, which bring together and represent the professionals who work in the discipline; and another conformed by the educational entities, focused on the Universities that approach the subject of Projects.

In order to define the target population for this research, a group selected to three methodologies proposed by the International Cooperation Agencies, three methodologies promoted by the Professional Project Associations and a methodology from the educational field, adopted by three universities belonging to the Funiber network, were selected.

Participants

The selection of methodologies for each of the three groups of organizations is presented below:

Methodologies of International Cooperation Agencies

International Cooperation Agencies (hereinafter more ICAs) are organizations that make up a complex global system of entities, whose various forms and relationships globally constitute the so-called International Cooperation System.

International Cooperation is the relationship established between two or more countries, organizations or organizations of civil society, with the objective of reaching agreed development goals.

ACIs have a long history of developing methods for project design and formulation. They have prepared a long list of methodologies aimed at obtaining the results expected for a development project. In general, each agency defines its own methodology to implement, and on many occasions, new methods or updated versions of existing ones are developed that imply an evolution with respect to those in use (Londoño, 2009).

For the purposes of this work, the three methodologies considered to be of greatest relevance will be analyzed, which in turn have set trends and can be associated with different periods depending on their period of greatest use. In chronological order they can be ordered as follows:

- Logical Framework Approach, from the US Agency for International Cooperation (USAID)
- ZOPP Methodology (Goal-Oriented Project Planning) of the German Agency for International Cooperation (GTZ)
- Management of the Project Cycle, from the European Union (EU)

The selection process took into account the progress already made by Natalia Londoño Vélez, author of the book *Formulación de Proyectos: Enfoques, procesos y herramientas* (Project Formulation: Approaches, processes and tools). In this material, an analysis of 40 different project formulation or planning methodologies developed by various ICAs is carried out, with the aim of contributing to consolidating the policies and methodologies of International Cooperation for Development in Latin America and the Caribbean

What is most interesting in this case of the work carried out by the author, are the results or conclusions she has reached. In the words of Londoño (2009):

> … In all the methodological models presented, the programming phase is equivalent to the dialogue and political principles that should guide cooperation projects. The identification phase is the first situational analysis of the project participants, problems, objectives and strategies. Formulation is the phase in which the project design is consolidated, the logical or results framework matrix is completed and the quality of the project design is verified, to make the decision about its financing. (p.3).

Here the author recognizes common points regarding the way to refer to the different phases of the project, and also common points regarding what these initial phases imply. This could be easily reflected in the comparison work carried out.

Professional Project Associations

The Professional Project Associations (PPA) considered most important according to their number of partners, for the dissemination of their bodies of knowledge and for the acceptability that exists regarding the proposed methodologies, are:

- The Project Management Institute, and its body of knowledge in project management known as the PMBOK (Project Management Body of Knowledge) currently in its 6th edition, (2017).
- The International Project Management Association and its body of knowledge called ICB (International Competence Baseline) currently in version 4 (2016).

- PRINCE2 (Project In Controlled Environment) methodology proposed by the OGC Office of Government Commerce of the United Kingdom, and its body of knowledge called Managing successful projects with PRINCE2, in its current 6th edition, (2017).

The Project Management Institute (PMI) is a nonprofit organization with more than half a million members. It is one of the world's largest professional associations offering project management certifications in 180 countries through compliance with management standards.

The PMI standards for project, program and portfolio management are recognized in the profession and it is their own PMI volunteers with project experience who develop and update these standards and provide a common language for project, program and program management. portfolios around the world.

The International Project Management Association (IPMA) is the world's first project management association. It is a confederation made up of more than 60 member associations, based in Switzerland. Its member associations promote the development of project management competencies in their geographical areas of influence, interacting with thousands of professionals and developing relationships with corporations, government agencies, universities and colleges, as well as training and consulting organizations.

The objective of IPMA is to develop professional skills in Project Management, and IPMA certification is a means of achieving excellence, not an end in itself. The certification is oriented towards a professional career plan in Project Management, based on the continuous development of skills in Project Management.

In the case of PRINCE2, this is the name of the methodology, and in its initial presentation, no specific mention was made of the professional association that promotes it because it is a somewhat more complex situation. The methodology was designed by the Computing Center and the UK Government Telecommunications Agency, and is the property of the Government Trade Office (OGC). Currently the methodology is promoted by AXELOS, a joint venture created in 2013 by the UK Government and the Capita company.

Despite being a development product of a government agency, its application widely transcends the borders of the United Kingdom, Prince2 has been adopted by different government agencies in different countries (Australia, Holland, Denmark, Canada, among others), by companies multinationals (DHL, BAT, Barclays, Vodafone, Shell, Unilever, Microsoft, HP, IBM, British Airways, among others) and International Organizations (the UN and its agencies, the World Bank, among others).

As in the case of ICAs, it is possible to find great similarities between the methodologies proposed by the different Organizations linked to the profession of Project Manager. Coincidences found in the proposed phases, in the processes proposed for each phase and in the instruments used to address certain issues.

Methodology in the field of Educational Institutions

Teaching in projects is applied mainly in the undergraduate and graduate levels, and generally each degree, program or subject chooses a methodology from those already mentioned in the development of its projects. Although there is also the case of universities or chairs that propose their own methodologies. For the development of this work we will analyze the project formulation methodology designed by the professors of

the Engineering area of the Polytechnic University of Catalonia, and adapted by the Universities of the Funiber network, for the dictation of their postgraduate project programs.

The Universities that use this methodology in their project programs are:

- International Iberoamerican University of Mexico
- International Iberoamerican University of Puerto Rico
- European University of the Atlantic

And the programs in which the methodology is used are:

- The Master in Project Management and Design,
- The Master in Architecture and Urban Planning Projects,
- The Master in Innovation and Product Projects,
- The Master in Project Design, Management and Administration for International Cooperation Projects.

The selection of this methodology is justified not only by the use and the great acceptance it has, but also because it proposes a series of innovative elements: it proposes the project planning process through practice, that is, through experience, Based on empirical knowledge, students develop a project based on the recognition of a conflict situation, need or opportunity.

Instrument

Documentary analysis has been the main constitutive resource of the investigation. In all cases the methodologies are found in documents, generally called bodies of knowledge or manuals. In some cases you can also find complementary publications promoted by these same organizations or by authors who are members of these.

A study was made of the latest versions edited by each of the organizations that promote the defined methodologies. Focusing on the recognition of the structure and composition of each of the phases, the processes or elements that compose them, and the instruments proposed for the development of the activities.

Tables were used to facilitate the comparison of the information between methodologies and tables to graph and synthesize information.

Data Analysis

To carry out the data comparison, and to facilitate the interpretation of the data, the following steps were carried out:

1. A first comparison was made between the methodologies proposed by each group of organizations (the methodologies proposed by the ICAs were compared with each other, and the same was done with the proposals by the PPPs) analyzing the different phases and the basic processes that compose them.
2. A synthesis table was made, which collected the common elements of the methodologies of each group of organizations (trying to overcome the differences in terms of how to refer to the phases and processes).
3. Three tables were prepared that, synthesizing the information previously analyzed on the basic phases and processes, reflected an analysis of the processes, elements and instruments that each group of methodologies proposed for each phase.

This allowed a simpler comparison of the characteristics of the methodologies at group level, that is, having previously recognized the characteristics that typify them.

Regarding the selection criteria, to include an element in the list of processes, components and instruments, the premise or condition that was established is that such element has been present in at least two of the three methodologies compared. It is necessary to clarify that sometimes the presence is not so evident because they are mentioned differently in one material and another, for this a detailed analysis of the descriptions of each element had to be carried out.

The purpose of these synthesis tables is to be able to show a standardized data, referring to the content of each group of methodologies, for each phase of the project, to facilitate comparison between the groups of methodologies.

Comparison of Life Cycles with their basic phases and processes, by group of organizations

The following is a comparison of the life cycles of ICA methodologies:

Table 1

Life Cycle of ACI methodologies

Logical Framework Methodology	ZOOP Methodology	Project Cycle Management Methodology
Phase I of Identification: - Analysis of participants - Analysis of Problems - Analysis of Objectives - Analysis of Alternatives Phase II of Design: - Project Planning Matrix - Activity Programming - Resource Programming - Feasibility Factors - Project Document Phase III of Execution and Follow-up: - Execution plan - Carrying out operations - Follow-up report Phase IV of Evaluation: -Evaluation of viability, impact, effectiveness, efficiency and relevance	Phase I Identification: - Identification of the central problem - Analysis of the causes and effects of the central problem - Analysis of Objectives - Analysis of Alternatives Phase II of Design: - Project Planning Matrix - Programming of Activities - Programming of Resources - Factors of Feasibility - Document of the Project Phase III of Execution and Follow-up: - Plan of execution - Carrying out operations - Follow-up report Phase IV of Evaluation: -Evaluation of viability, impact, effectiveness, efficiency and relevance	Phase I of Programming - Analysis of political orientations - General Principles Phase II of Identification: - Diagnosis on the idea of the project Phase III of Instruction or Formulation: - The design of the project Phase IV of Financing is consolidated: - Feasibility Study Phase V of Execution and Monitoring: - Use of resources -Analysis of effectiveness and efficiency Phase VI of Evaluation and Audit

Below is a synthesis table resulting from the comparison of the life cycles of the ICA methodologies, recognizing the basic processes of each phase:

Table 2
Synthesis table of the Life Cycle of the ICA methodologies:

Phases of ACI Methodologies	Basic processes of each phase
Phase I of Programming	- Political Diagnosis - Analysis of Cooperation and Development Policies
Phase II of Identification	- Situational analysis of: participants, problems, objectives and strategies - Institutional Capacity - Technical Feasibility Studies
Phase III of Formulation	- Framework Matrix and definition of: objectives, products, activities, hypotheses, indicators with baselines, sources of verification, preliminary schedules, budget and economic analysis. - Evaluation of the Design of the proposal: assessment of the quality criteria and development factors - Writing the Project Document
Phase IV of Execution	- Operations Plan - Executing operations - Progress and monitoring report
Phase V of Evaluation	- Analysis of relevance, effectiveness, efficiency, impact and viability - Progress report and monitoring

Below is a comparison of the life cycles of PPP methodologies:

Table 3
Life Cycle according to PPP methodologies

Project Management Institute	International Project Management Association	PRINCE2
Phase I of Initiation: - Act of Constitution of the Project	Phase I of pre-investment: - Ex-ante evaluation -Preconceptual Engineering	Preliminary Project Phase I: -Planning of the initial scenario - Start-up of the project
Phase II of Organization and Preparation: - Statement of the Scope and objectives - Plan of action - Baseline	Phase II of Investment: - Execution - Monitoring - Reports - Delivery	Phase II of the Initial Scenario: - Creation of the Project Plan (for scenario 1) - Review of the initial Plan
Phase III of Execution of the project: - Progress according to Plan of Action - Monitoring and control Acceptance - Approval	Phase III of Operation: - Evaluation of results - Lessons learned	Phase III of Project Execution: - Review of the Scenario 1 planning - Execution of Scenario 1 Plan

Phase IV of project closure: - Delivery	- Preparation of Scenario 2 Plan (Repeated as many times as scenarios are proposed). Phase (n) of Project Closing: - Delivery

Below is a synthesis table resulting from the comparison of the life cycles of the PPP methodologies, recognizing the basic processes of each phase:

Table 4

Synthesis of the Life Cycle of the PPP methodologies

Phases of PPP Methodologies	Basic processes of each phase
Phase I: Start - Planning	- Project Planning - Preconceptual Engineering - Project Constitution Act - Action Plan
Phase II: Execution –Operation	- Progress according to Action - Plan Monitoring and control Acceptance and approval - Evaluation of Results
Phase III: Closing	- Delivery - Lessons learned

Below is a table recognizing the basic processes of each phase of the life cycle according to the methodology proposed by the universities of the Funiber network:

Table 5

Life Cycle according to the methodology of Educational Institutions

Methodology of Educational Institutions
Phase 1: Identification of the Problem - Delimitation of the problem, scope, involved and requirements
Phase 2: Preliminary - Definition of the solution system, the associated risks, human and material resources required. - Evaluation of investment and operating costs and transmission process to the future management team.

Phase III: Detailed Engineering - Detailed studies required for execution Phase IV: Assembly and Construction - Execution - Monitoring and follow-up Phase V: Commissioning and Assignment - Reports - Delivery - Evaluation of results - Lessons learned

Comparison of processes, components and instruments proposed for each Phase:

Below is a table containing the phases common to the group of methodologies represented by the ICAs, which also indicates the processes, components and instruments that make up each phase:

Table 6
Processes, components, and instruments of the ACI.

Phases	Processes or components	Instruments
Identification Phases	Political Diagnosis Identification of needs Analysis of Problems Analysis of Objectives Analysis of Stakeholders Objective Tree Identification of alternatives Strategy selection Definition of Actions	Problem Tree Effects Tree Cause Tree Objective Tree Matrix for assessing the power and interest of those involved Action Tree
Programming Planning Phases Formulation	Definition of Variables and Indicators Definition of assumptions Determination of means of monitoring and control Analysis of risk factors	Matrix Project Planning Matrix Structure Analytical of the Project Matrix Logical Framework Matrix of means of verification Results measurement technique
Execution Phases Evaluation	Execution of the operations Conclusions intermediate evaluation Problems and actions intermediate evaluation Monitoring and evaluation	Plan of Operations Progress and monitoring report Ex post or impact evaluation

Below is a table containing the phases common to the group of methodologies represented by the PPPs, which also indicates the processes, components and instruments that make up each phase:

Table 7
PPP processes, components, and instruments

Phases	Processes or components	Instruments
Planning Phases: -Pre-investment - Preliminary project -Organization and preparation	Project Start-up Process Project Planning Process Scope Management Plan Schedule Management Plan Cost Management Plan Quality Management Plan Human Resources Management Plan Communications Management Plan Risk Management Plan Procurement management plan Stakeholder management plan Project Management Process Plan Project team development and management Plan Management of the parties involved	Project Constitution Act (in English: charter) Stakeholder analysis matrix Labor Division Structure Matrix of Assignment responsibilities Task schedule Organizational chart
Execution Phases: - Monitoring and control - Evaluation - Closing	Communications management Project Process Project team development and management Management of the parties involved Communications management Project Phase Control Process Follow-up and control of Project Product Delivery Management Process Quality assurance Integrated change control Schedule control Risk control Procurement control Contract administration	Breakdown of Organizational Structure Method Earned method PERT method ROY method Schedule Control Diagram Gantt Project Milestone Plan Cost Analysis Variance Method Cost Systems by Activity Request for Proposal Techniques Supplier Selection Techniques Contract Administration Techniques Risk Assessment Matrix Quality Management Techniques Quality Audits Cost

		Classification Economic evaluation indicators: VAN, TIR, TD. Environmental impact assessment techniques
Closing Phase	Limits Management Process Validation and scope control Project Closing Process Project closing or phase Closing of acquisitions	

Below is a table that contains the phases of the methodology of educational institutions, which also indicates the processes, components and instruments that make up each phase:

Table 8
Processes, components, and instruments of the methodology proposed by the universities of the Funiber network.

Phases	Processes or components	Instruments
Definition Phase	Identification of the Problem Recognition of the Causes Contextualization of the problem Identification of Limitations Identification of those involved	Table of definition of the context of the problem Matrix for evaluating the power and interest of those involved Ishikawa diagrams Matrix for evaluating requirements Matrix for contrasting requirements and limitations
Planning Phases	Recognition and assessment of the requirements of those involved Definition of a system that provides a solution to the problem Development of the basic components of the system Definition of the human and material resources required to development and subsequent operation Risk Identification Assessment of the impact on the environment Budget development and investment schedule Project assignment process	Flowcharts Structure of the Division of Labor Organization chart Matrix for assigning responsibilities Environmental impact study Simplified Risk Assessment Technique Investment Schedule Budget

Execution Phases	Not addressed in the methodology of educational institutions. In the master's degrees in question, this is developed in the Management and Direction Modules, where it is proposed to apply what is proposed by the PPPs

Results

Results of the comparative analysis of the Life Cycle of the ACI methodologies

There is a notable coincidence between the phases and the basic processes of each of the methodologies. The project formulation stage itself is preceded by a programming - identification instance, destined to frame the project within an institutional political context. Then the planning-formulation phase continues where the basic components of the project are developed, determining the future actions and the role that each of the participants will have. Subsequently, the execution-monitoring stage continues. It does not provide great concepts or tools nor does it specify the same detailed division of processes that is exposed in the initial phases, rather it specifies how to carry out the monitoring of activities, but not how it is executed. And finally, there is an evaluation phase in which aspects of effectiveness, efficiency, impact, feasibility and relevance are analyzed.

These results are in line with those proposed by Londoño (2009), who points out:

> Although each agency presents differences in the number and name of the phases to structure a project, as well as slight variations according to institutional philosophy and emphasis on one or another methodological approach, the meaning, as well as the processes that make up each phase, are almost identical and comparable. Substantially three common and central phases in the construction of a project can be pointed out: planning, implementation and evaluation. (p. 27).

This can be explained in the sense that this type of project always tends to achieve the development and benefit of a certain group of people, with the commitment and participation of different actors, and with cross-cutting approaches and analyzes that promote equity in a community. As are, among others, environmental and gender perspectives.

Results of the comparative analysis of the Life Cycle of PPP methodologies:

From the analysis of the life cycle, the basic phases and processes of PPPs, it is also possible to recognize that there are greater coincidences than differences, generally starting with an initial phase- planning-formulation that does not require previous instances, where the tasks are focused on developing the action plan or the project plan. It is continued by an execution-monitoring phase, where what is defined in the initial instance is carried out, constantly controlling, monitoring and evaluating the processes and results. Subsequently, a closing phase is developed, in which the deliveries of the developed products are made and the completion of contracts and other contractual relationships.

Results of the analysis of processes, elements and instruments of the methodologies proposed by the ICAs:

From this analysis it could be deduced that the methodologies of the ICAs dedicate a lot of time and effort to the preliminary definitions that are aimed at determining the beneficiary community or group, the problems central, the perceptions of the same on the part of the actors involved, the strategies and alternatives of action, that is, a series of processes that precede the determination of the action plan. At the same time, the processes, elements and instruments proposed for the execution and monitoring phases have much less development, and even attend almost exclusively to the control function over the application of activities, but without defining how to apply or develop such activities.

Results of the analysis of processes, elements and instruments of the methodologies proposed by the PPPs:

In contrast to what was verified in the ACI methodologies, in the case of the PPP methodologies, it can be seen that the processes start with the definition of the action plan, that is, the preliminary definitions of what it is intended to do seem to be already defined and not part of the planning processes. This is clearly represented in the case of the PMI Life Cycle where it is stated that the start of the project follows from the directive of the company management on a specific requirement.

On the other hand, the number of processes and instruments proposed for the implementation and monitoring phases are notably more numerous and complex, which denotes a greater dedication and concern for these instances.

Results of the analysis of processes, elements and instruments of the methodologies proposed by the Educational Institutions:

In the case of this methodology, it can be seen that both in the definition of the phases of its life cycle and in the instruments proposed for each instance, there is an evident coincidence with the methodologies proposed by the ACI. In relation to the execution and monitoring phases, there are no elements to make the comparison since this methodology is focused on the planning and formulation processes but not on the management and execution processes. Such contents are addressed in the analyzed master's programs, in different modules, where the application of the instruments and processes developed by IPMA and the PMI is proposed.

Results that allow the comparison of the processes, elements and instruments of the three groups of organizations:

Comparing the results obtained in the three tables, we can see that there is first a difference in terms of the phases in which one and the other methodologies are structured, taking The proposals by the ICAs and the methodology of the educational field have much in common, but having great differences with those proposed by the APPs.

The first (ACI and educational institutions) focus on "what to do", and show great dedication in the previous instances of definition or programming, where it is intended to establish a framework for action and try to define a consensus scenario with actors who will be beneficiaries or that they will be influenced by the intervention; while the second

(APP) focus on the "how to do it", having previously defined and determined what it is intended to achieve.

This is clearly reflected in the processes, elements and instruments proposed for each phase by each group of methodologies: a superiority in quantity and complexity of the factors analyzed in the preliminary phases for the ICAs and the methodology of educational institutions is observed, while such superiority is found in the treatment that PPP methodologies make of the management and execution phases.

Discussion and conclusions

Conclusions of the results of the investigation

Based on the results obtained by the investigation, and clarifying that this does not attempt to be representative of all the existing cases, but rather the population defined as the object of study of this investigation, we can establish the following conclusions:

- The project methodologies proposed by the ICAs are focused on the initial processes, attending to the preliminary definition and programming of the actions, but avoiding fundamental processes of project execution.
- The project methodologies proposed by the PPPs have less development of the preliminary instances compared to those proposed by the ICAs, but the aspects related to the project execution instances are much more developed, with a very complete battery of instruments intended to the application and execution of activities.
- The methodology proposed by the universities of the Funiber network, as conceived by the project programs, is focused only on planning instances and has great points of coincidence with the methodologies proposed by the ICAs, proposing different starting points, and may also be adaptable to the development of projects in the private sphere. The methodologies proposed by the ICAs are recommended for projects with defined intentions, linked to promoting the development of a community or region, but often with uncertainty regarding the way to obtain or achieve said results.
- The methodologies proposed by PPPs are recommended for projects that have defined the product or service that they intend to achieve or offer, and that require the definition of processes to achieve said results.
- Despite having different starting points in the three groups of methodologies, these are essentially complementary; In the cases in which projects are developed by the ICAs, for the development of the execution phases it is possible to use the processes, elements and instruments proposed by the PPPs.
- Complementarity of methodologies is also possible when companies (which generally use PPP methodologies) develop projects with an impact on the community or the environment. In these cases, using the processes and instruments proposed by the ICAs can be essential to achieve project success.

Graphical representation of the results

The following graph shows the phases adopted by each group of methodologies.

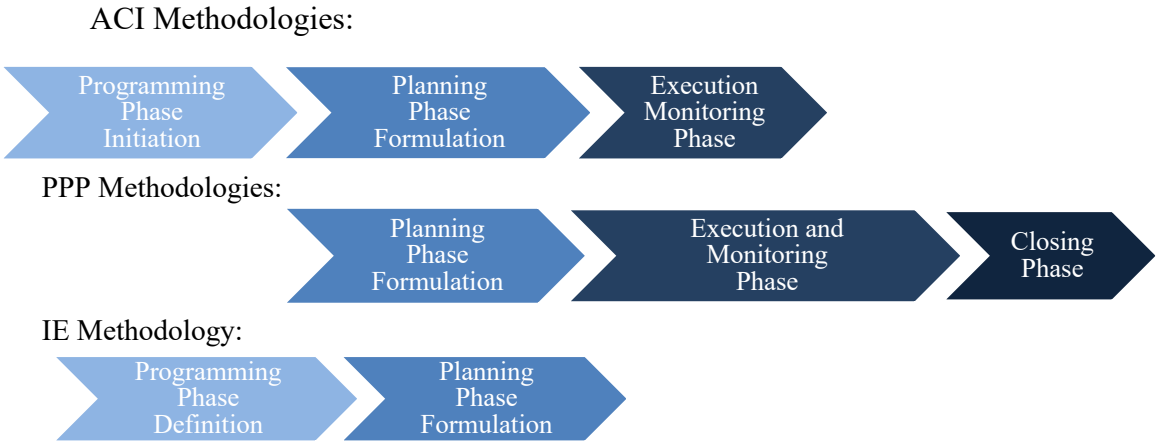

Figure 1. Phases for each group of methodologies

Below is a graph that represents the dedication according to the number of processes, elements and instruments proposed for each phase, differentiated by groups of methodologies:

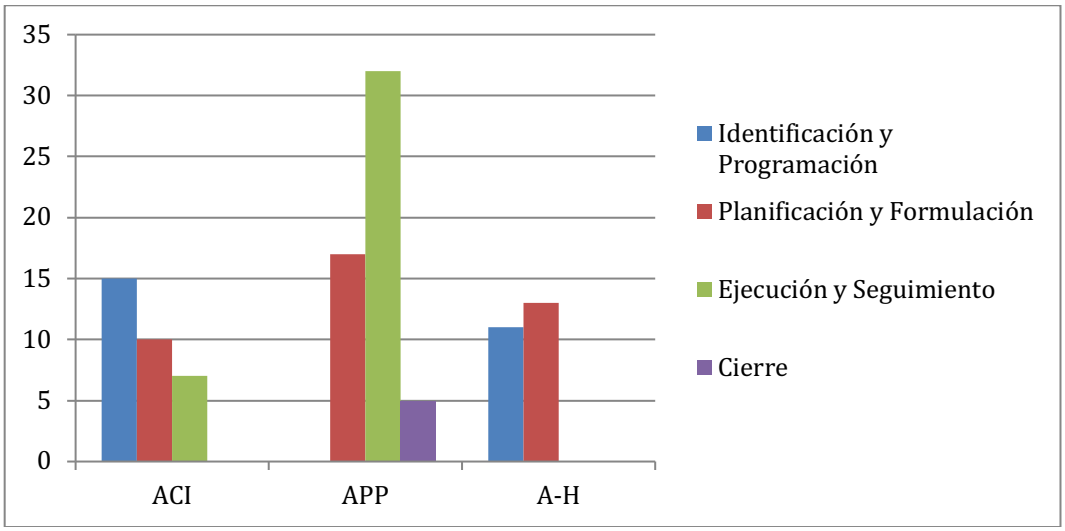

Figure 2. Processes, elements, and instruments of each phase in each group of methodologies.

Reflection of the author

Work in undergraduate university teaching applying ACI methodologies and in postgraduate teaching where we apply the methodology of the universities of the Funiber network; I am also a member of the Argentine Association of Project Management in which we promote the use of methodologies developed by PPPs. Based on this experience, I can say that, despite the clear differences between the types of methodologies and their applicability, this does not seem to be evident for professionals in the area. It is common for university professors to be unaware of the instruments and resources that PPP methodologies provide for the execution of projects, and in the same

sense, it is sometimes surprising the disinterest that exists even on the part of PPP professionals, regarding the instruments and applicability of ACI methodologies.

It is frequent, then, that this potential that disciplinary integration provides us is wasted as many times those who are dedicated to planning are unaware of the virtues of management tools, and those who are dedicated to execution, do not take into account the benefits of methodologies. Planning.

General conclusions

The comparison of the contents and graphics allows us to reaffirm the observed trend regarding the object of study or work of both organizations. In the case of ACI methodologies, the highest level of detail is focused on the initial definition, planning and formulation processes, corresponding to the design tasks of the professionals involved; while the material available and promoted by PPPs, presents a more exhaustive development in the execution phases, concerning the management and direction tasks of the professionals.

This is mainly due to the reasons that lead in both cases to develop the projects. In the case of Development projects, promoted by the ICAs, the motivation is to benefit a community or group of people, so the form or through which product or service will be specified is not defined, and therefore these initial phases they are more extensive and require more time, tools and particular methods for such a definition; On the other hand, in the type of projects that are approached from the PPPs, many times there is already the objective to be achieved and even the definition of the product to be achieved or the service to be offered, predetermined by the managers of the organization or by the clients of the company. In these cases, less time and resources are required for the most basic and initial definitions of the project.

In projects developed by a company, which continue the logic of PPP methodologies, it is common for the project owner and its executor to be the company itself, therefore, the methodologies propose a battery of operating instruments for management, administration and direction processes; on the contrary, in the projects promoted by the ICAs, it is common for the owner and executor of the project to be an NGO, or a civil society institution or organization that is advised, accompanied and sometimes monitored. Therefore, the instruments they propose for these instances aim at control rather than execution of operations.

This is evidenced in the postulated in the Logical Framework Methodology manual for planning, monitoring and evaluation of projects and programs of the Latin American and Caribbean Institute for Economic and Social Planning. In this document that dedicates 95% of its content to the Design and formulation aspects, the authors Ortegón, Pacheco and Prieto (2005) affirm:

> The Follow-up or Monitoring is carried out during the execution stage of a project and not in others stages of the project cycle. It is a systematic procedure used to check the efficiency and effectiveness of the project execution process to identify achievements and weaknesses and recommend corrective measures to optimize the desired results. (p.47)

The Logical Framework methodology proposes as an integrating element between the planning phase and the execution phase, the Monitoring and Evaluation Plan. In this regard, Oregon et al (2005) states: "It is worth noting that without establishing a good M&E plan, the Project Manager does not have the basic element of management in their hands" (p. 50)

References

AEIPRO-IPMA. (2009). *NBC-Bases para la Competencia en Dirección de Proyectos*. Valencia: Editorial UPV.

AXELOS (2009). *Managing Successful Projects with PRINCE2.* London: Editorial Van Haren Publishing.

AXELOS (2017) *Managing Successful Projects with PRINCE2® 2017 Edition First Edition, Second Impression.*

Blasco, J. (2003). *Los proyectos de sistemas artificiales: el proyectar y lo proyectado*. Barcelona: Ediciones UPC.

Camacho H. Et. Al (1999). *El enfoque del marco lógico: 10 casos práctico.* Madrid: Fundación CIDEAL y Acciones de Desarrollo y Cooperación.

Cejas, C.; Olaviaga, S.; Kremer, P. (2006): *Manual para la formulación de proyectos de organizaciones comunitarias*. Buenos Aires: CIPPEC

Comisión Económica para América Latina y el Caribe –CE- PAL. Instituto Latinoamericano y del Caribe de Planificación Económica y Social –ILPES. (2005) *Metodología del Marco Lógico para la planificación, el seguimiento y la evaluación de proyectos y programas*.

FUNIBER. (2017) *Material del Módulo de Diseño de la Maestría en Proyectos.* Barcelona: Fundación Universitaria Iberoamericana

Gómez, M., Sinz, H. (2003). *El ciclo del proyecto de cooperación al desarrollo*. CIDEAL. P. 221.

IPMA International Project Management Association (2015). *NCB4 Competence Baseline*. International Project Management Association.

Londoño Vélez, N. (2009). *Formulación de Proyectos: Enfoques, procesos y Herramientas. Escuela Latinoamericana de Cooperación y Desarrollo*.

Ministerio de Asuntos Exteriores de España. Secretaría de Estado de Cooperación Internacional y para Ibero América (1997). SECIPI: *Metodología de evaluación de la cooperación española*. Madrid.

Osorio, S., Zamora, V., Jimenez, M. y Macias, H. (2015). Guía Metodológica para el Diseño de Proyectos de Intervención de la Práctica Educativa. *Revista de Docencia e Investigación Educativa*, 1 (1), 39-48. Retrieved from https://dialnet.unirioja.es/servlet/articulo?codigo=6367046

Planificación de Proyectos Orientada a Objetivos (ZOPP). (1998) *Deutsche Gesellschaft für Technische Zusammenarbeit* –GTZ. GmbH, Eschborn.

PMI, Project Management Institute. (2017). *Guía de los Fundamentos para la Dirección de Proyectos (Guía del PMBOK)* (6ª Ed.). Pennsylvania: Project Management Institute.

Reyes, J. E., y Martínez Almela, J. (2013). *Procesos de Proyectos y Competencias en Dirección de Proyectos*. Valencia: Editorial UPV.

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METHODOLOGY TO DEVELOP OPTIMAL WELDING PROCESSES OF THERMOPLASTIC MATERIALS (EVA AND EVA / EVOH) USING THE HIGH FREQUENCY WELDING SYSTEM (HF)

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Abstract. The use of plastic materials has increased enormously in recent years. Currently there are lot of industrial and domestic companies that manufacture their products using the process of welding of thermoplastics with the high frequency welding (HF) technology. But when initializing their processes to manufacture products, they make the adjustments with the "trial and error" method until obtaining the optimal parameters with which the manufacturing equipment will be operated. This entail a series of expenses that impact the costs, quality of the product and damage to the environment due to the waste of discarded products. The production by means of processes of welding of thermoplastics using the system of high frequency (HF), is an integral part of the majority of the main processes of manufacture. The purpose of the methodology is to propose the development of optimal welding processes of thermoplastic materials (EVA and EVA / EVOH) using the high frequency welding system (HF), providing a benefit of reducing or eliminating the loss of time, resources, waste of materials, unnecessary expenses, obstacles and errors, reaching the goal of the process. The results of the answer show that the experiment # 27 the process has a Cpk of 2.98 and the experiment # 25 has a Cpk of 3.36, giving way to the methodology, where statistically allows to obtain a 6 Sigma process. In addition, the methodology allows to obtain the operational parameters of the thermoplastic welding process in control, reliable and predictable. It allows to have a process that can produce quality products to remain competitive in a growing global market.

Keywords: High frequency (HF), dipole, polarization, dielectric, thermoplastic welding.

METODOLOGÍA PARA DESARROLLAR PROCESOS ÓPTIMOS DE SOLDADURA DE MATERIALES TERMOPLÁSTICOS (EVA Y EVA/EVOH) USANDO EL SISTEMA DE SOLDADURAS DE ALTA FRECUENCIA (HF)

Resumen. El uso de materiales plásticos se ha incrementado enormemente en estos últimos años. Actualmente hay una gran cantidad de compañías industriales y domésticas que manufacturan sus productos usando el proceso de soldadura de termoplásticos con la tecnología de soldadura por alta frecuencia (HF). Pero al inicializar sus procesos para manufacturar productos, realizan los ajustes con el método de "prueba y error " hasta obtener los parámetros óptimos con los que se operarán los equipos de manufactura. Esto conlleva una serie de gastos que impactan el costo, calidad del producto y daño al medio ambiente por el desperdicio de productos descartados. La producción mediante procesos de soldadura de termoplásticos usando el sistema por alta frecuencia (HF), es parte integral de la mayoría de los principales procesos de manufactura. El propósito de la metodología es proponer el desarrollo de procesos óptimos de soldadura de materiales termoplásticos (EVA y EVA / EVOH) utilizando el sistema de soldadura de alta frecuencia (HF), aportando un beneficio de reducir o eliminar la pérdida de tiempo, recursos, desperdicios de materiales, gastos innecesarios, obstáculos y errores, llegando a la meta del proceso. Los resultados para la respuesta muestran que el experimento #27 el proceso tiene un Cpk de 2.98 y el experimento #25 tiene un Cpk de 3.36, dando paso a la metodología, donde estadísticamente permite obtener un proceso de 6 Sigma. En adición, la metodología permite obtener los parámetros operacionales del proceso de soldadura termoplástica en control, confiable y predecible. Permite tener un proceso que pueda producir productos de calidad para seguir siendo competitivos en un mercado global en crecimiento.

Palabras clave: Alta frecuencia (HF), dipolo, polarización, dieléctrico, soldadura termoplásticos.

Introduction

Plastic welding is a process for joining parts made of thermoplastic materials. Welding takes place by softening the areas to be joined. The polymer molecules acquire certain mobility by the action of an external agent (heat, vibration, friction, solvent). When both pieces are joined and pressure is applied, the molecules of both parts that need to be joined interact, interweaving. Once the action of the external agent is finished, the molecules' movement decreases, leaving an interlaced structure and forming the union of both plastic parts.

There are various welding processes for joining plastics on the market. Therefore, the ideal application of each of them depends on many factors.

Among the most common technologies in the industrial market for welding thermoplastic materials are:

- Hot plate welding.
- Heat-sealed.
- Laser welding.
- Ultrasonic welding.
- High frequency (HF) welding.

Thermoplastic welding using high-frequency technology is the process of melting and joining thermoplastic materials together using electromagnetic energy. Two electrodes create an oscillating electric field that begins to change as the polar molecules move within the materials, to orient themselves according to the electric field. The movement of these molecules releases energy in the form of heat and when enough energy is applied, the thermoplastic material begins to melt and bond with each other.

Currently, many industrial companies use this technique for different products: Medical Devices (IV drug container bags, blood bags, saline bags, oxygen bags, and bags for storing and maintaining sterile medical tools), automotive (plastic folders, heel pads or mats and seams for convertible covers and canvas covers), stationery (albums, book covers, diary covers, ID cards, folders, cardholders), consumer goods (umbrellas, raincoats, plastic bags, plastic covers, belts, gloves, guts, backpacks, and mixed fabric seals) and recreational goods (inflatable toys, balls, air cushions, inflatable ponds, waterbeds, product packaging), that manufacture their products using the thermoplastic welding process with high frequency (HF) welding technology.

Commonly, when initializing their processes to manufacture products, they make the adjustments with the method of "trial and error" until they obtain the optimal parameters with which the manufacturing equipment will operate (because they are subjected to factors like the type of material, "preheating" temperature, pressure, current, time of weld and the stage of weld cooling). Therefore, they can obtain a quality weld. This has an impact on the cost, quality of the product, and damage to the environment due to the waste of discarded products.

The article is structured into four topics and references, in addition to the summary and introduction and document structure. The methodology developed with optimal welding processes will allow the industrial sector to improve the quality of the final product and reduce costs associated with product waste.

In the first topic, we will address the definition of HF (high frequency) welding and the principle of plastic welding, to show a global vision of this technology.

The second topic is dedicated to thermoplastic materials, carrying out a summary of the principles, performances, and properties of these materials, to know how to interpret their performance. Besides, the theory of radio frequency (RF) welding is explained with its characteristics, and the operation of the HF welding generator is explained and identified.

The third topic will address the optimization where the use of the methodology is explained. An approach to identify, analyze, evaluate and design the experiment (DOE) that allows us to define the significant variables ("preheating" temperatures, pressure, current, welding time, and welding cooling time) is described as well. These are the parameters that affect the conditions in the welding process of thermoplastic materials using the welding system (HF), to optimize the results and thus be able to obtain statistical data independently.

Subsequently, different experimental design methods will be carried out to characterize some types of thermoplastic polymers that will be welded with the high-frequency technology. Besides, the results will be evaluated by their quality in the welding process.

The fourth topic is dedicated to results. The results obtained are discussed, highlighting the current limitations of the methodology. To evaluate the improvement of the thermal welding process with thermoplastic materials, the visual inspection methods with the magnification system and the welding resistance method will be used. Finally, the conclusion and contributions of this article are presented.

Method

What is HF welding?

The process of high-frequency welding (HF), also known as radiofrequency (RF) and dielectric welding, involves the fusion of material by supplying HF energy in the form of an electromagnetic field (27.12 MHz) that is normally applied between two metal electrodes, plates or molds. HF welding is accompanied by some pressure or force on the surfaces of the material that is going to be joined.

> Radiofrequency welding or (high-frequency welding) is the process of joining materials by using electromagnetic energy. Two electrodes create an oscillating electric field that begins to move and to shift the polar molecules within the materials, to orient themselves according to the electromagnetic field. The movement of these molecules releases energy in the form of heat. When enough energy is applied, the molecules begin to melt and bond with each other. Taken from (United Foam Plastics [UFP] Technologies, 2020)

Thermoplastic Materials

> They are materials that can be deformed thanks to heat and compression, maintaining their new shape when cooled. However, they can be softened by heat and re-molded, maintaining their physical and chemical properties when they return to their initial state of rigidity after cooling. Taken from (Wikiversidad, 2019).

Nevertheless, all thermoplastic materials cannot be welded using a high frequency, as they must have other specific characteristics, especially regarding their molecular structure (dipole), their dielectric constant, and their loss factor.

Electric dipole

> An electrical dipole is formed by two charges, one positive and one negative of the same value, separated by a certain distance. However, we can also define a dipole as a neutral system in which the center of the positive charges do not coincide with the center of the negative charges. A typical example is the water molecule. As oxygen is more electronegative than hydrogen, there is an accumulation of negative charge on the side where the oxygen is, and of positive charge on the opposite side. Taken from (Wiki, 2017).
>
> The unique structure of the polar water molecule, H2O, is the basis for the thermal response of water when subjected to an alternating field of RF energy. Taken from (Radio Frequency, 2019)

Water is polar due to the difference in electronegativity between the hydrogen and oxygen atoms. The highly electronegative oxygen atom attracts negatively charged electrons, making the areas around the oxygen more negative than the areas around the two hydrogen atoms. Therefore, the hydrogen side of the molecule is relatively positive to the negative side of the oxygen.

Podržaj and Čebular (2016, p. 1064) state the following:

> The molecules of the material used must have an electric dipole moment, which is defined as $p = \vec{I}Q$p" = " I ⃗"Q" , where p is the electric dipole moment and $\vec{I}$I ⃗ is the displacement vector that points from the negative electric charge -Q

to the positive electric charge $+Q$. When this type of molecule is in an electric field (E), the torque (T) interacts with each other. The torque result is given by Equation 1:

$$T = p \cdot E \quad (1)$$

Chemical Structure

The polymer molecules that form a thermoplastic are linked together by intermolecular bonds, forming linear structures such as semi-crystalline or branched thermoplastics as amorphous thermoplastics. We could resemble its structure to a set of strings in which each one is a polymer. The strings may be intertwined, with greater force applied to separate each polymer molecule. Van der Waals' forces between the polymer molecules that form a thermoplastic material can be of different degrees depending on the chemical composition of the molecule itself and the spatial arrangement that it adopts. Depending on this, the adopted structure can be either amorphous or crystalline and both can exist in the same material. The amorphous structure is characterized by a disorderly dispersion of the polymer chains. Besides, it is responsible for the elastic properties of the plastics. The greater the number of amorphous structures is, the greater the elasticity of the thermoplastic, but it will have less resistance. In the crystalline structure, the polymer molecules are arranged in an orderly manner. Also, they are much more compact than in the amorphous structure. The intermolecular forces are stronger. Therefore, the crystalline structures confer mechanical resistance properties to the thermoplastic materials, making them resistant to loads, traction, and temperature. However, the greater the number of crystalline structures, the less elasticity there is and the more fragile it becomes. There are dozens of thermoplastics types and in each of them, the crystalline/amorphous organization and density vary. Nowadays, the most widely used thermoplastics are polyurethane, polypropylene, polycarbonate, and acrylics.

Amorphous and semi-crystalline thermoplastics performance

At room temperature, plastic is a hard material. Macromolecules are held together by intermolecular forces, and can barely move. If the temperature increases, the mobility of these macromolecules increases, as well as their elasticity and toughness. However, the strength of the material decreases. On the other hand, molecular orientation brings with it mechanical properties that affect the process. The mechanical characteristics of these materials can be illustrated with a rigidity versus temperature table, as shown in Figure 1. The vertical coordinate indicates the rigidity, and the horizontal coordinate indicates the temperature of the material.

The graph profile of amorphous materials will show that, at low temperatures, the material will remain in a solid-state. As the temperature increases, the material reaches a state called the vitreous state. This is characterized by the Glass Transition Temperature, (Tg). After this vitreous temperature Tg, the material will enter a transition zone known as the vitreous zone, where it will gradually lose its rigidity. When the glass transition temperature (Tg) is exceeded, the intermolecular forces become so small that when an external force acts, the macromolecules can slide over each other. Resistance drops considerably while lengthening increases sharply. In this temperature range, the plastic is in a thermo-elastic state, similar to the one of rubber. The vitreous zone can be seen in Figure 1. If the temperature continues to increase, a completely soft material will be obtained, similar to an elastic or rubbery melt that is not a liquid. Besides, the intermolecular forces are very small and tend to disappear. The plastic passes continuously from the

thermo-elastic state to the molten state. This transition is characterized by the range of melting temperatures. In this case, we are not talking about a specific temperature. Figure 1 shows the vitreous zone Tg, the vitreous state zone, and the region corresponding to the soft zone.

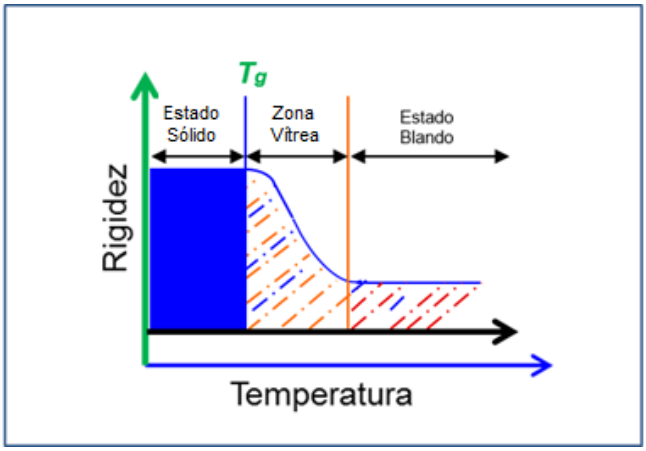

Figure 1. Profile of amorphous materials in the soft state zone.

Note: Source: Author's creation.

If the plastic heating continues, at some point, the chemical structure of the plastic gets decomposed. This limit is defined by the decomposition temperature (Tz).

> If the macromolecules have little branching, that is to say, few and short side chains, then it is possible that certain areas of the molecular chains are organized and arranged in a compact way next to each other. These highly ordered areas within the molecule are called crystalline regions. However, it should be taken into account that perfect or complete crystallization never occurs, as the chains' length prevents this from happening, even during polymerization when the chains start to intertwine with each other. Therefore, apart from the ordered regions, a part of the molecule always remains disordered, with regions distant from each other, called amorphous regions. Thermoplastics with both crystalline and amorphous regions are called semi-crystalline thermoplastics. Taken from (Wikiversidad, 2019).

Semi-crystalline thermoplastics are never transparent, not even when they are in their natural, uncolored form, but, because of the scattering of light on the border between the amorphous and crystalline regions of the plastic, they always look milky or cloudy. Figure 2 shows the performance of stiffness as a function of temperature for semi-crystalline materials. For this profile, it can be seen that, at a certain low temperature, the material is in a solid-state. This solid-state is represented in Figure 2 by the area marked with blue, in which the stiffness does not have important variations with the temperature. As with amorphous materials, at low temperatures, the material remains rigid and increasing temperature, it will reach the vitreous zone, just from the temperature called Tg, which is indicated in Figure 2. When talking about partially crystalline (semi-crystalline) materials, it is not common to use the term Tg. If the temperature continues to increase, beyond the vitreous zone, the material will lose some of its rigidity. In semi-crystalline materials, the vitreous zone is insignificant and corresponds to the amorphous part of the materials. Even so, it will remain in the solid-state. Figure 2 shows this vitreous zone.

If the temperature continues to increase, the melting temperature, $T_{m,}$ will be reached.

After $T_{m,}$ a liquid material is obtained. This is why it is said that semi-crystalline materials melt and do not soften like the amorphous ones.

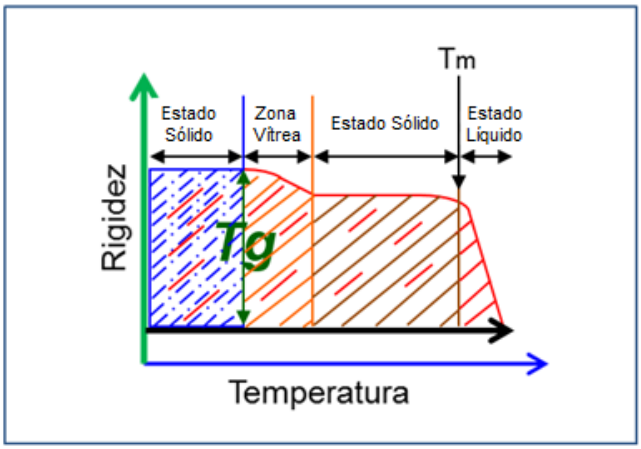

Figure 2. Profile of semi-crystalline materials in the liquid state

Note: Source: Author's creation.

Note that semi-crystalline materials do not have a large processing area like the amorphous ones, this makes it more difficult to melt. On the other hand, in the inverse process where the material is in the molten state and it is taken to the solid-state (decreasing the temperature), the process zone occurs faster than in the case of the amorphous materials. Figure 2 shows this performance.

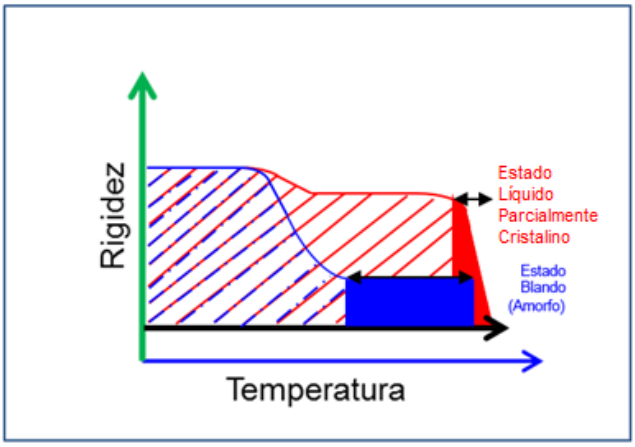

Figure 3. Graphic profile of semi-crystalline vs. amorphous materials.

Note: Source: Author's creation.

In Figure 3, it can be seen that the graph of rigidity vs. temperature shows a difference between amorphous and semi-crystalline polymers. The amorphous polymer clearly shows the three regions of visco-elastic performance: vitreous (visco-elastic), rubbery, and soft. Although there are differences in the timescale for the different polymers, the general shape of the curve is the same for all.

However, in semi-crystalline polymers, the phenomenon of the glass transition is covert in semi-crystalline thermoplastic materials, as these melt at temperatures higher than the glass transition of the amorphous zones.

The semi-crystalline areas, made up of sections that extend into the amorphous areas, act as anchorage centers, making it difficult to soften the material and it performs as if it were reticular.

Electric heating.

Welding (HF) is based on this principle, which largely depends on the characteristics of the materials used.

The dielectric heating loss is a phenomenon of the materials that are subjected to an alternate high-frequency (HF) electric field. When the current passes through the material, it loses some of its energy, which is propagated in the material.

- If there is no material, the electric current passes through the field without losses: its intensity remains the same at the beginning (A) and at the end (B). (Figure 4).
- If a dielectric material is in the field (C), some electric current will dispel in it: its intensity will be stronger before crossing the material (A) and lower afterward (B). (Figure 5)

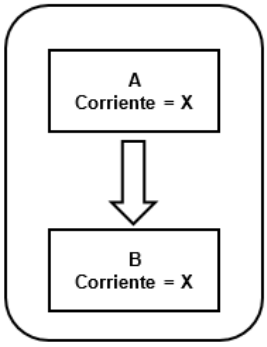

Figure 4. Without dielectric material.

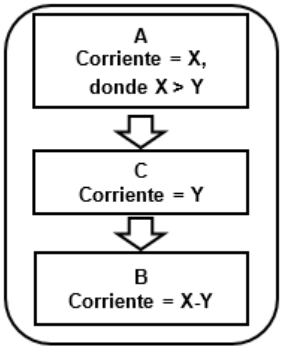

Figure 5. With dielectric material.

Note: Source: Author's creation

Naldini, Bianco, Amado, Nolasco and Perez (2016, pp. 2700-2701) state the following:

> In addition to this effect, there is also the heating produced by the dielectric losses due to conductivity, which develops within the RF current. At low frequencies, the power dispelled in the dielectric material is low due to the rapid alignment of the dipoles with the electric field, and the dielectric losses are negligible. As the frequency increases, the alignment of the dipoles becomes out of phase with the electric field, with a marked increase of dielectric losses. This results in a transformation of the field energy into heat.

During the process of dielectric losses, part of the energy is absorbed by the material and it is not returned. What happens then with that small part of the energy? According to the law of conservation of energy: "Energy is neither created nor destroyed, it is only transformed". And then, this energy has not disappeared, it has just been transformed into something other than electricity.

Dielectric constant

All materials have physical, chemical, or electrical characteristics, and one of them is the dielectric constant (ε). This material-specific dielectric constant is given for a specific frequency (for example, 10 MHz) and a precise temperature. Specifically, this dielectric

constant indicates the ability of a material to be electrically charged. Besides, it is calculated regarding an insulating material base: water, whose ε = 1.

To calculate the constant, 3 steps are necessary:

Step 1: Calculate the voltage.

To transfer the energy, the material must be placed between two electrodes: one grounded and the other subjected to a high-frequency alternate voltage (HF). The voltage creates an electric field (E) between the two electrodes, expressed in V/m.

Using Voltage Equation 2, this electric field can be calculated,

$$E = V/d \tag{1}$$

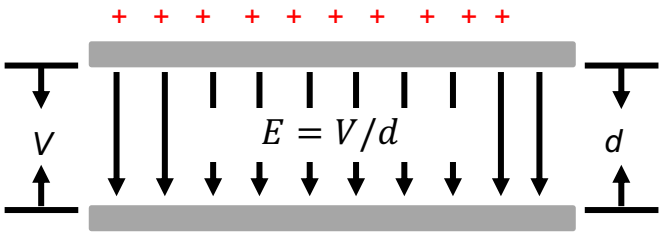

Figure 6. Dielectric constant in thermoplastic material.

Where,

- E = voltage
- V = electric field voltage
- d = *distance* between the electrodes

Step 2: Calculate the electric displacement

Electric induction (also called electric displacement field) is a field of the vector denoted by $\vec{D}\left(\vec{r} * \omega\right)$ as a function of spatial position and angular frequency. It is expressed in C/m².

Where,

- $\vec{D}$ = electric displacement
- $\vec{r}$ = function of the position in space
- ω = angular frequency or electromagnetic pulse

Step 3: Calculate the dielectric constant

Using the two calculations done, the expression $\varepsilon = D / E$, that is the dielectric constant of a material whose unit is in farads per meter (F/m), is deduced.

Where,

- ε = dielectric constant of the material
- D= electric displacement
- E= voltage

This constant allows us to choose the best material and the best welding parameters, but also, as it is the case of our devices, to calibrate a sensor device that controls the performance of the material and the welding.

As stated at the beginning, the dielectric constant depends on the frequency, but can also vary depending on factors such as humidity, temperature, structure, or composition of the material.

- Moisture, for example, influences the dielectric constant of a material, because water is a dipole. In fact, if water is present in an HF weld, the dipole molecules of the water will absorb the electrical energy.
- Temperature can also influence the dielectric performance of the material: the higher the temperature is, the greater the dielectric loss.
- The structure of the material is also a factor to consider, as it affects the performance of the dipoles. A material can have a crystalline or amorphous structure: as part of a solder (HF), the structure of the material must be amorphous.

The material composition is also important because the dielectric constant of a material, composed of several products, depends on the dielectric constants of the different products that form it. In general, the presence or addition of solvents or additives, polar or saline, increases the dielectric loss.

Optimization

To achieve the optimization of a thermoplastic welding process using high-frequency technology, a systematic methodology has been developed. This allows us to improve the welding process. The methodology of parameterization of the thermoplastic welding process using high frequency (HF) system helps to identify the initial parameters. Besides, it helps to eliminate the process of the traditional method of "trial and error", minimizing the process activities that do not add value (product rejecting - loss of production time being the least competitive product in the market) to create a faster and more efficient process. This leads to a transformation of the product or service in a functional way. But at the same time, it is good for the first time, and, at the end of the process, satisfies the client and makes the process to be cost-effective.

During the process of thermoplastic welding using high frequency, several variables involve the production of the final product, which may have different qualities in the finished products. Through experience, the traditional method of "trial and error" has been used to find the appropriate values for the variables involved. Therefore, it is necessary to determine the convergence of the variables that define the production process, which is better known as process optimization.

The research aims to replace the traditional "trial and error" method with a more engineering and formal way to identify the problems and successes of each decision-making during optimization, starting using new molds and changing the material to use the same mold.

To optimize the thermoplastic welding process using high frequency (HF) system, it is recommended to use the parameterization flowchart of this process system. See Figure 4-7.

As a starting point, it is necessary to have the specifications of the product that is going to be welded. In this phase, the functionality and purpose of the final product are defined and explained, and the corresponding information is obtained to verify or confirm the compatibility with the high-frequency technology.

The second phase continues with the identification of the characteristics, dielectric, mechanical and thermal, of the thermoplastic material to be welded. The purpose is to know its performance and compatibility with radio frequency technology and molds definition (electrodes) and mathematical calculations according to their applications, leading to the verification of the design already completed or the electrodes' new design to be made. At the same time, the specifications of the thermoplastic provided by the manufacturer are verified.

In the third phase, the specifications of the machine provided by the manufacturer are developed for the identification and specification of the mold press, type and specifications of the molds (electrodes), HF generators, and material voltage systems. The purpose is to understand the ranges of operational parameters available to be used in the experiments (DOE), for the identification of the process critical variables.

For the fourth phase, we continue with the compatibility checks of the machine vs. the product to be welded, to verify if the machine can weld the product meeting the required product specifications.

In the fifth phase, we carry on with the characterizations of the thermal, mechanical, and electrical main stations of the machine, which in turn are related to the significant variables (HF voltage, pressure, and welding time) of a thermoplastic welding process using high-frequency technology.

For the sixth phase, we continue with the development of the design of experiments (DOE) to search for the optimal parameters of the significant variables (Percentage of the Variable Capacitor-HF Voltage, Applied Pressure (Force), Welding Time, Temperature of the Mold Cooler).

In the seventh phase, the design results of experiments (DOE) are evaluated and the optimal parameters of the significant variables are determined. The suggested parameters are then confirmed, and the process is analyzed statistically. The repeatability and consistency of the process will be evaluated with a statistical program.

In the research work, we use the MiniTab program to evaluate the process capability "Process Capability".

As a starting point, the dielectric and mechanical characteristics of thermoplastic materials for the welding process were determined. Afterward, we continued with the development and analysis of the high-frequency technology and preliminary procedures of the area to be welded. This allowed us to identify the problems that may arise at the time or after the welding process.

Then, the characterization of the thermoplastic welding process was presented. This allowed the determination of the process of significant variables. This leads as well to the development of the experiment designs that allowed to optimize the significant variables of the thermoplastic welding process.

For the parameters 150 Kg, 200 Kg, 300 Kg, and 450 Kg of press 1, where we had an average of a Cpk = 4.76, equivalent to a 6 Sigma process, where statistically it allows us to observe that the process is controllable, reliable and predictable.

- The parameter 150 Kg, had a Cp 5.22 with a Cpk 3.69, for a 6 Sigma. (See Figure 7).
- The parameter 200 Kg, had a Cp 7.83 with a Cpk 5.90, for a 6 Sigma. (See Figure 8).
- The parameter 300 Kg, had a Cp 5.22 with a Cpk 4.63, for a 6 Sigma. (See Figure 9).
- The parameter 450 Kg, had a Cp 5.87 with a Cpk 4.82, for a 6 Sigma. (See Figure 10)

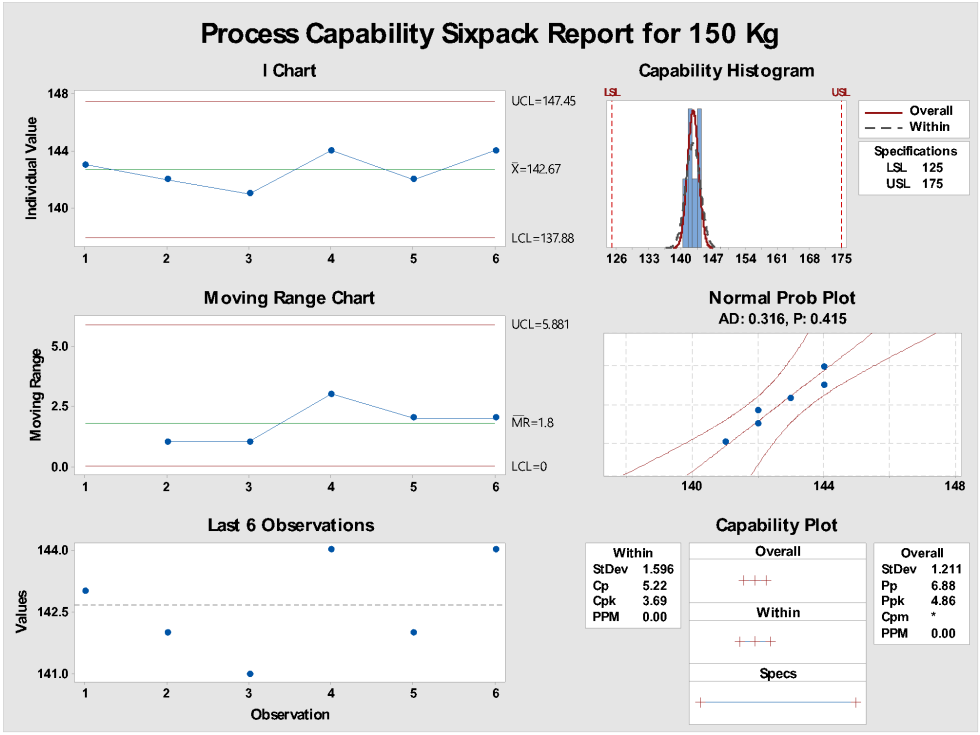

Figure 7. Process capacity of press 1 at a force of 150Kg

Note: Source: Author's creation.

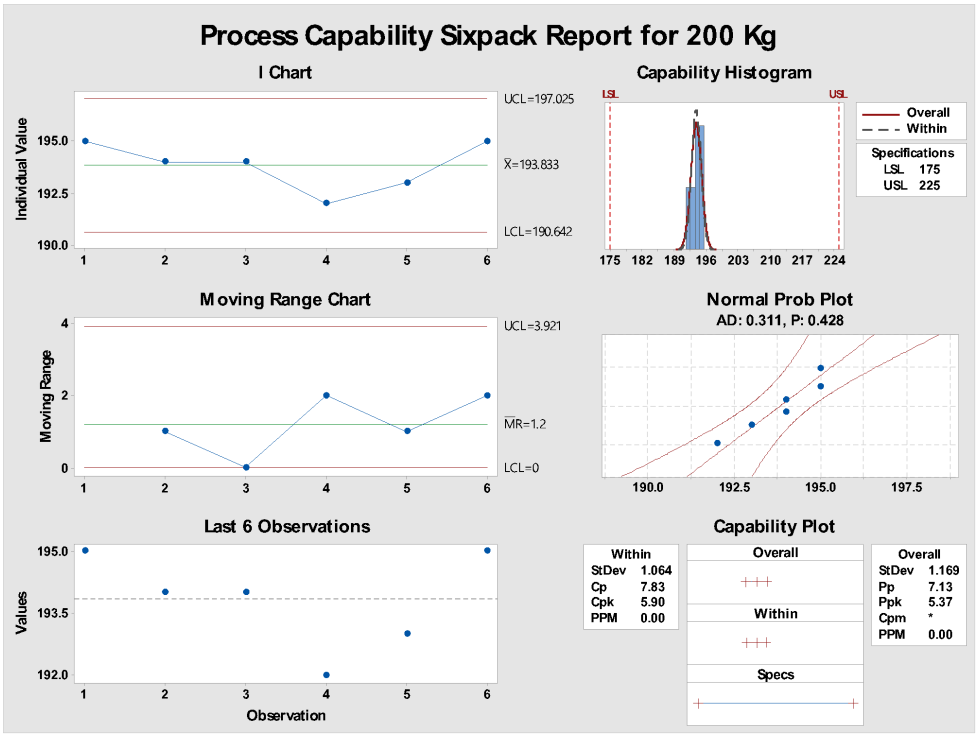

Figure 8. Process capacity of press 1 at a force of 200Kg

Note: Source: Author's creation.

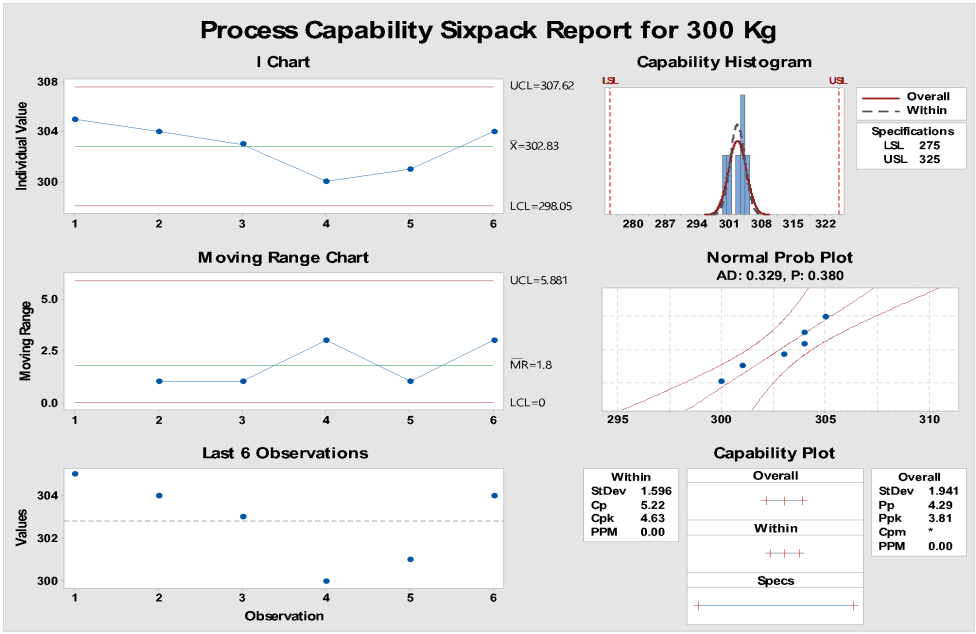

Figure 9. Process capacity of press 1 at a force of 300Kg

Note: Source: Author's creation.

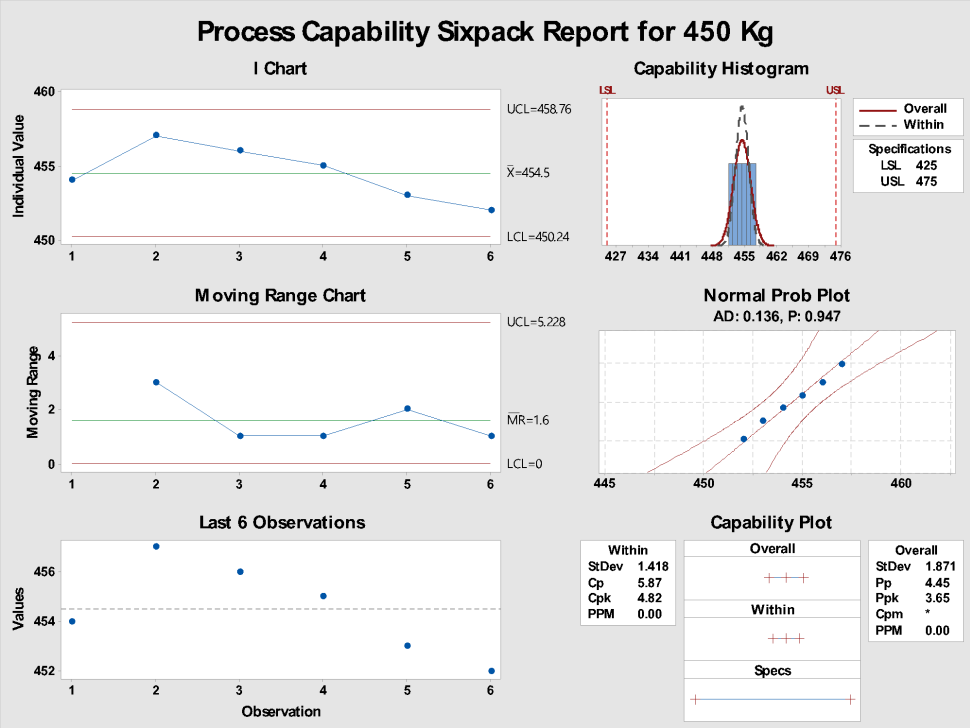

Figure 10. Process capacity of press 1 at a force of 450Kg

Note: Source: Author's creation.

For the parameters 850 Kg, 1050 Kg, 1750 Kg, and 1900 Kg of the press 2, where we had an average of a Cpk 3.66, equivalent to a 6 Sigma process.

- The parameter 850 Kg, had a Cp 17.67 with a Cpk 7.75, for a 6 Sigma.
- The parameter 1050 Kg, had a Cp 4.70 with a Cpk 1.88, for a 5.5 Sigma.
- The parameter 1750 Kg, had a Cp 4.70 with a Cpk 3.16, for a 6 Sigma.
- The parameter 1900 Kg, had a Cp 3.92 with a Cpk 1.83, for a 5.5 Sigma.

Based on the results of the presses' characterization, we can conclude that the performance of presses 1 and 2 are of high efficiency because both had similar process windows. This leads to a qualification window with the same tolerance for both, since the tolerance of the force parameters is approximately 8 times higher than the result obtained in the qualification window of each of the presses. This gives a result of a Cpk of 1.67, which is equivalent to a 5 Sigma process, obtaining a process higher than the industry standard, where the Cpk is 1.33.

After completing the experiment designs (three factors with three variables), the variables selected were: Percent of Variable Capacitor, Welding Time, and Mold Cooler Temperature (electrodes). These variables were analyzed with the MiniTab program using the main effects graph, where the main effects graph analysis is defined by examining the differences between the level means for one or more factors because there is a primary effect when different levels of a factor affect the response differently.

In Figure 11, the graph illustrates the main effects of the different variables: (Percent of Variable Capacitor, Welding Time, and Temperature (°C) of the Mold Cooler), showing how they affect the response (weld thickness) differently.

Analyzing the variables versus the product specification, where the weld thickness values must be between 0.35 millimeters and 0.45 millimeters, it should be observed that when the line is not horizontal (not parallel to the X-axis), then there is a primary effect. Different factor levels affect the response differently. The steeper the slope of the line is, the greater the magnitude of the main effect (thickness of the weld).

Obtaining the results, the variable that most affects the thickness of the weld is the Welding Time because its slope is more aggressive (because the line is not parallel to the X-axis). This response confirms the result that was observed in the experiments, where there was stated that the longer the welding time is, the thickness of the weld approached the lower limit of the specification and if the time continued to increase, there was sometimes a "flash" in the weld (Figure 12). Figure 11 also illustrates that the second factor that affects is the Cooling Temperature of the molds (electrodes), concluding that at higher temperatures (°C), the cooling time increases the weld melting, as the material becomes softer before the weld is applied. Finally, there is the percentage of the Variable Capacitor, since its result is almost linear to the response of the weld thickness. This is because the capacitor responds to the resistance of the material, but while the thermoplastic material is changing its solid state to a soft state. The effect of the thermoplastic material becomes more conductive, because of this effect, the capacitor tends to control its power faster.

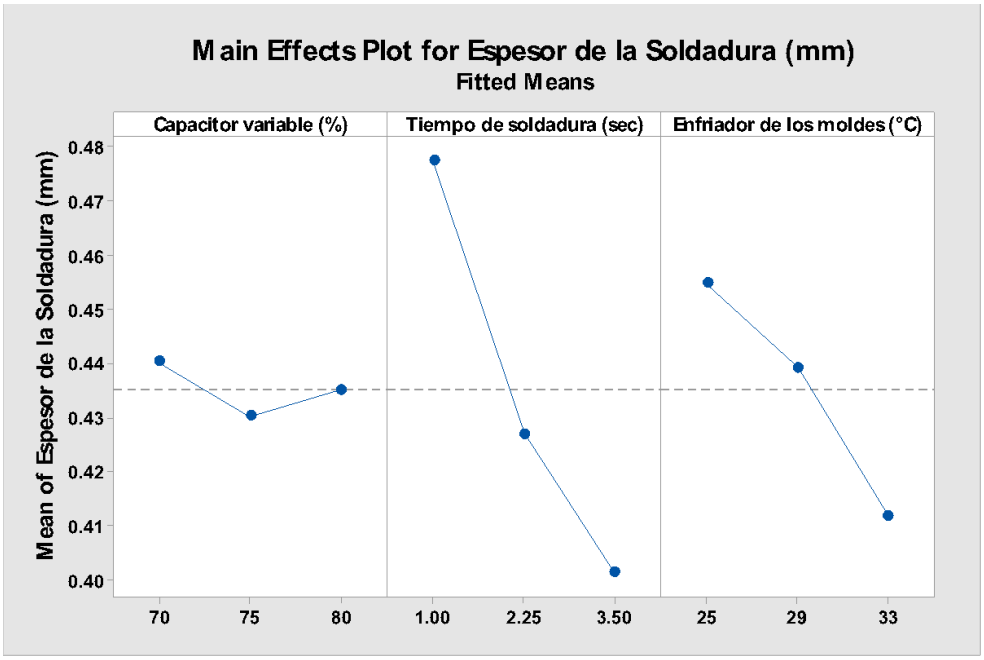

Figure 11. Main effects of the three significant variables

Note: Source: Author's creation.

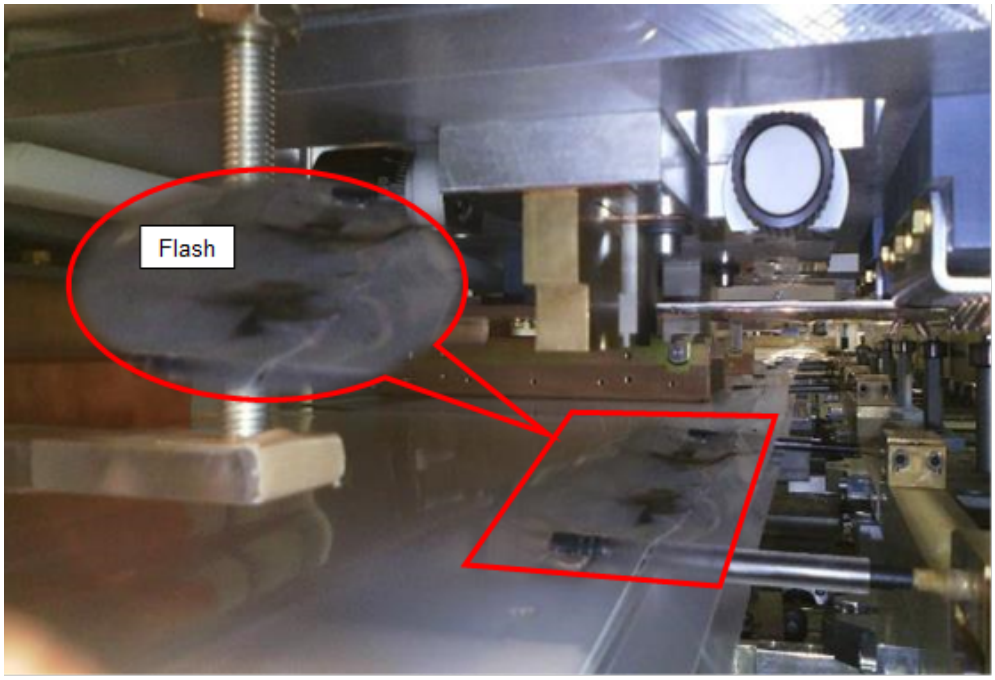

Figure 12. "Flash" effect on thickness specification welding

Note: Source: Author's creation.

By analyzing Figure 13, it is possible to illustrate the interactions of the variables for the response, which is the thickness of the weld.

Within the three comparisons, we see that the combination that has the greatest interaction with the weld thickness is the temperature (°C) of molds cooling (electrodes) and the time of welding. This confirms the results obtained from the experimental designs and the analysis of the main effects graph. Statistically, it allows us to observe that the response of the thickness of the material, that is the fusion of the thermoplastic material, is proportional to the combination of the molds' temperature (electrodes), and the time of weld is greater, the effect of the thermoplastic material in arriving at T_m is aggressive. Figure 14 shows the melting of the thermoplastic material, but with an excess of material over the welding. Figure 15 shows the material welding, but with some measurements outside specifications (lower limit). Also, Figure 16 shows, by the visual inspection method, that the performance of the weld is not uniform, because it creates some flaws in the weld where the thermoplastic material is delaminated. In conclusion, the cooling time variable of the solder is not being efficient as the molds are hot. Besides, it affects the melting of the thermoplastic, having found that the EVOH material is a semi-crystalline thermoplastic. This effect is because the cooling time of the solder is responsible for cooling the solder made, to prevent the semi-crystalline thermoplastic material from continuing to increase the temperature and going beyond the T_m zone, where the effect is negative. After all, when passing this zone, the thermoplastic material goes into a liquid state affecting the quality of the solder.

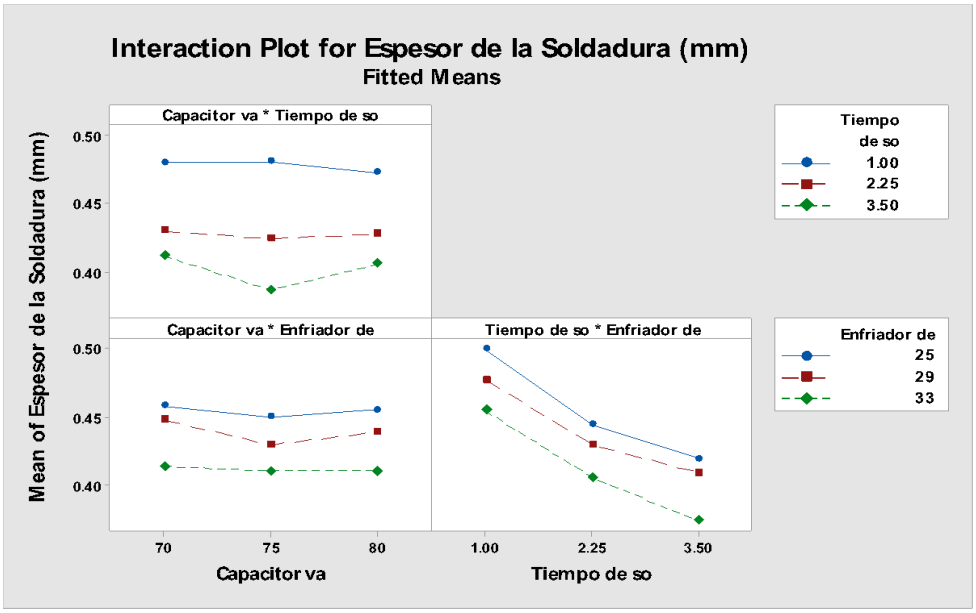

Figure 13. Interaction of the three significant variables

Note: Source: Author's creation.

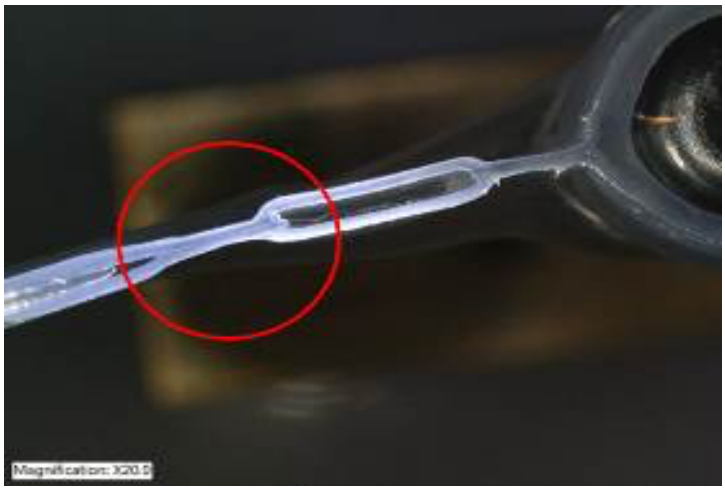

Figure 14. Material on weld with displaced material

Note: Source: Author's creation.

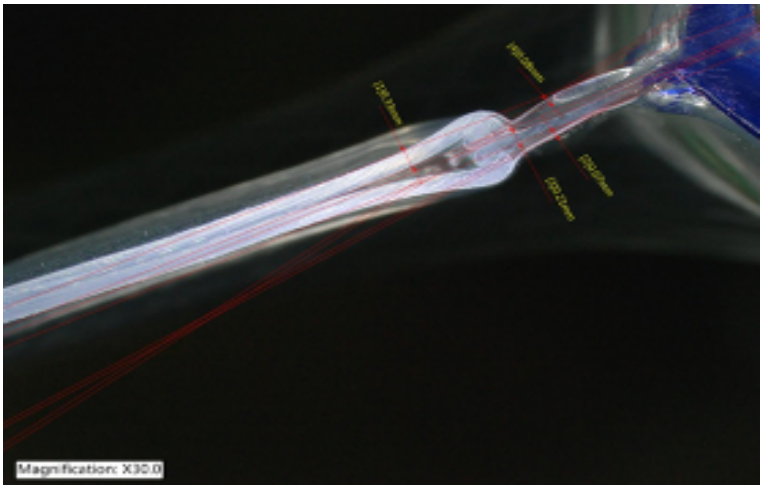

Figure 15. Measurements of material on weld

Note: Source: Author's creation.

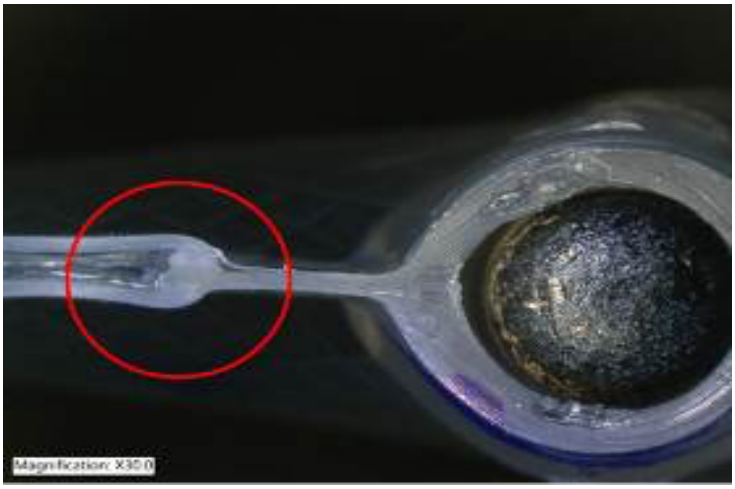

Figure 16. Welding rejected by visual inspection

Note: Source: Author's creation.

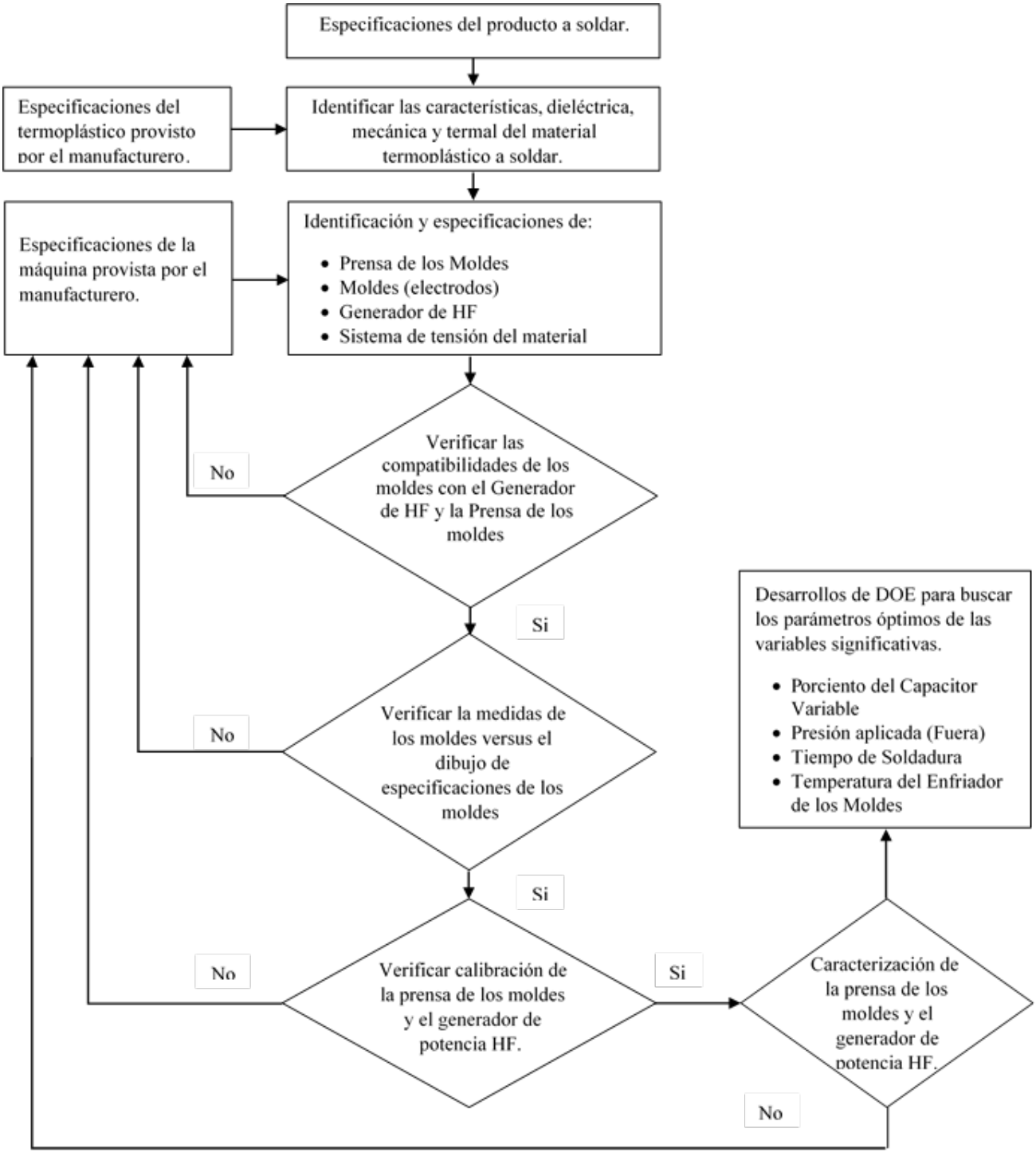

Figure 17. Methodology that enables the development of optimal processes for processes using high frequency (HF) technology.

Note: Source: Author's creation.

Results

Based on the results of the field research, the significant variables data was analyzed.

Parámetro	Valor Mínimo	Valor Promedio	Valor Máximo
Parámetro del % del capacitor variable	70 %	75 %	80 %
Tiempo de soldadura	1 sec.	2.25 sec.	3.5 sec.
Temperatura del enfriador de moldes	25 °C	29 °C	33 °C
Especificación del espesor del material soldado.	0.35 mm	0.40 mm	0.45 mm

Número de Experimento	Capacitor Variable (%)	Tiempo de Soldadura (sec.)	Enfriador de moldes (°C)	$\bar{X}$ de Espesor de Soldadura (mm)	Desviación Estándar (σ)
Experimento #27	70 %	2.25 sec.	33 °C	0.403 mm	0.015 (σ)
Experimento #25	75 %	3.5 sec.	25 °C	0.405 mm	0.010 (σ)
Experimento #7	80 %	3.5 sec.	29 °C	0.418 mm	0.013 (σ)
Experimento #26	70 %	3.5 sec.	29 °C	0.424 mm	0.014 (σ)
Experimento #1	75 %	2.25 sec.	29 °C	0.425 mm	0.012 (σ)
Experimento #15	80 %	3.5 sec.	25 °C	0.427 mm	0.013 (σ)
Experimento #21	70 %	3.5 sec.	25 °C	0.428 mm	0.007 (σ)
Experimento #12	70 %	2.25 sec.	29 °C	0.429 mm	0.015 (σ)
Experimento #22	80 %	2.25 sec.	25 °C	0.431 mm	0.008 (σ)

Figure 18. Summary of experiment designs

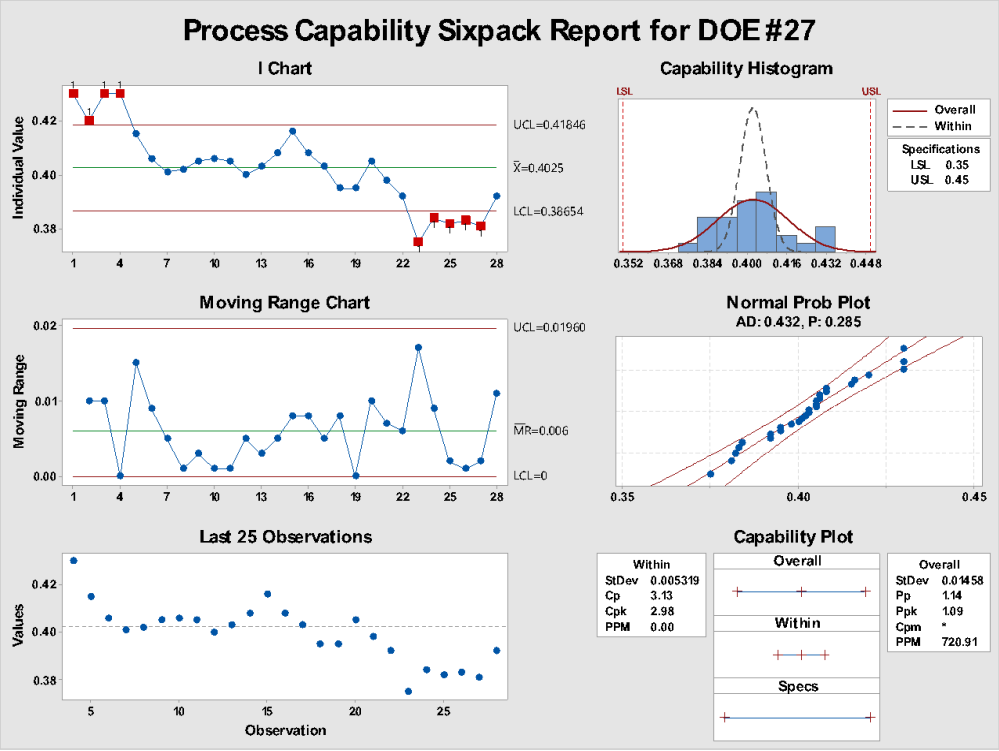

Figure 19. Experiment process capability #27

Note: Source: Author's creation.

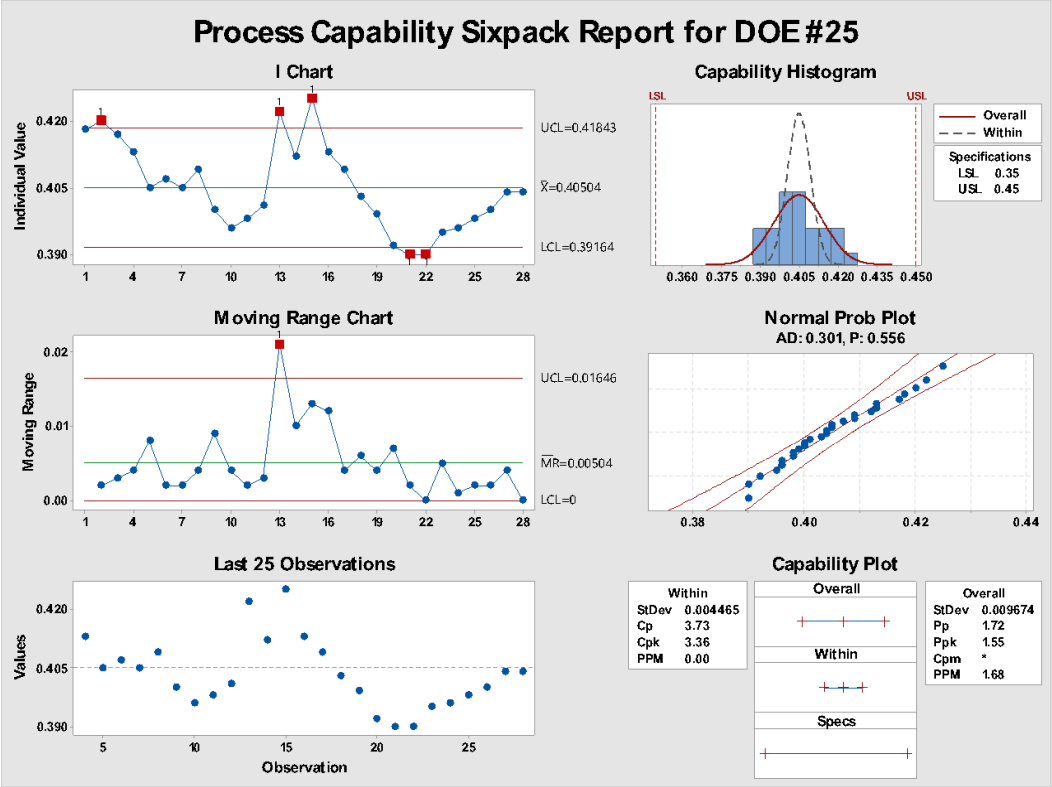

Figure 20. Experiment process capability #25

Note: Source: Author's creation.

Concluding with the results' information on the experiments carried out, nine out of twenty-seven experiments were obtained (Figure 18). In them, the acceptance criteria were fulfilled (visual inspection and dimensioning of the weld thickness). As a result of the nine experiments that met the acceptance criteria, there are two (experiments 27 and 25) that were accepted for the research and validation of parameters and processes. This is because one of the most important acceptance criteria is the average weld thickness and the two experiments had significant results, meeting the nominal value of the weld thickness specification (as shown in Figures 21 through 23) and allowing a range of adjustment in all three variables (Percent of Variable Capacitor, Welding Time and Mold Cooler Temperature) for process variations. And as a second important factor, standard deviations of 0.010 (σ) and 0.015 (σ) were obtained in the welding process of the thermoplastic material. Finally, experiment #27 shows in Figure 19 that the process had a Cpk of 2.98, and, in Figure 20, experiment #25 had a Cpk of 3.36. This leads to the methodology, where statistically it allows to obtain a 6 Sigma process, fulfilling a controlled, reliable, and predictable process.

Figure 21. Acceptable weld, tube release test versus EVA or EVA/EVOH layer

Note: Source: Author's creation.

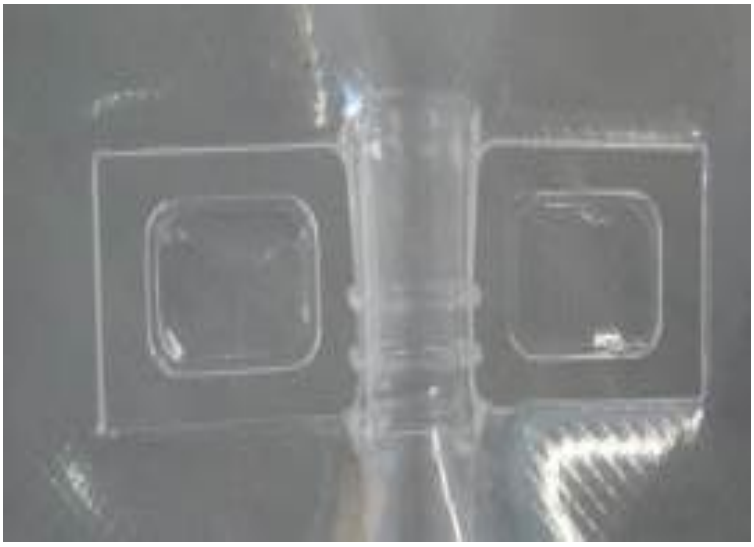

Figure 22. Acceptable weld, visual test

Note: Source: Author's creation.

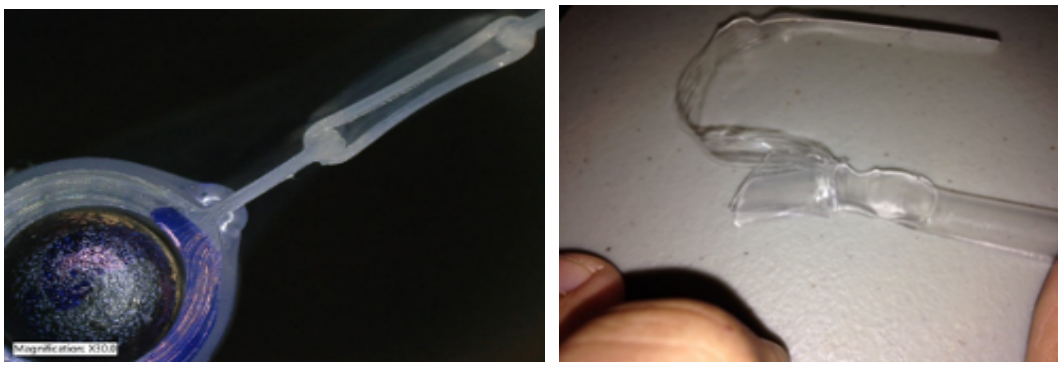

Figure 23. Acceptable weld, visual test and tube release test versus EVA or EVA/EVOH layer

Note: Source: Author's creation.

Discussion and conclusions

In the field research, it is concluded that, from the present work, it was observed that in different manufacturing companies in the manufacture of thermoplastic welding machines using a high frequency, an internal process is carried out to calculate the high frequency (HF) power generators based on their knowledge, technology, and experience. However, a standard methodology to start up the machine with the product is not carried out.

The parameters found from the characterizations and the designs of experiments differ in quantitative questions, for their different values, but in qualitative question, they are very similar. This is widely noticed in the characteristics of the force press and in the generators of high frequency, where it was predicted in which parts of the zone or process of the weld, the quality is going to be deficient. Besides, having conducted the welds varying the principal variables, it was observed that the variables indicated in experiment designs were present the ranges of parameters that influence directly in the principal defects.

The protocol proposed in the present work can be applied to obtain the most important parameters of the thermoplastic welding process with a high-frequency system in new electrodes (molds) or change of thermoplastic types. This is important since most of the time the electrodes (molds) are tested by changing the parameters randomly without a control, although it is necessary to use a lot of material in the application of the protocol. But in the end, you can identify the optimal values to use during production and you have a record of the defects found with different values in the parameters. Also, it is a tool that will help optimize the process.

In comparison with the work experience against the protocol, in the first one, it is possible to obtain acceptable parts in all aspects and without the use of much materials. Figure 17 shows a flow chart that was developed during the research, providing support to get a strong process. Where it is possible to develop optimal processes for processes using high frequency (HF) technology.

The disadvantages of scientific molding are the use of a lot of material for testing and the time spent on it. We can add the fact that scientific molding cannot be fully applied with engineering thermoplastic materials.

Statistical analysis serves to identify the variables that affect the part in a quantitative way. This is important since it is not based on the operator experience.

References

Naldini, G., Bianco, F., Amado, J., Nolasco, S., Pérez, M. (2016). Radio- Frequency Welder of PVC Tubes for Medical Applications. *IEEE Latin America Transactions, 14*(6), 2700–2701. doi: 10.1109 / TLA.2016.7555241

Podržaj, P., Čebular, A. (2016). The Application of LVQ Neural Network for Weld Strength Evaluation of RF-Welded Plastic Materials. *IEEE Latin America Transactions, 21*(2), 1063-1071. doi: 10.1109 / TMECH.2015.2498278

Radio Frequency, Inc. (2019) Cómo funciona la calefacción RF. Retrieved from https://radiofrequency.com/general-industry/rf-heating/

Wiki. (2017) Dipolo eléctrico (GIE). Departamento de Física Aplicada III, Universidad de Sevilla. Retrieved from http://laplace.us.es/wiki/index.php/Dipolo_el%C3%A9ctrico_(GIE)

UFP Technologies, Inc. (2020) ¿Qué es la soldadura RF (alta frecuencia)? Retrieved from https://www.ufpt.com/resource-center/rf-high-frequency-welding/

Wikiversidad. (2019) Termoplásticos. Retrieved from https://es.wikiversity.org/wiki/Termopl%C3%A1sticos

Ruiz, K. (2017). *Metodología para desarrollar procesos óptimos de soldadura de materiales termoplásticos (EVA y EVA/EVOH) usando el sistema de soldaduras de alta frecuencia (HF).* (Tesis Doctoral no publicada). Universidad Internacional Iberoamericana México (UNINI-MX).

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DESIGN OF A MANAGEMENT MODEL IN THE PREPARATION AND EVALUATION OF PROJECTS

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Abstract. This article presents part of the findings of an investigation aimed at designing a methodology for the elaboration of a management model (MdG), as a basic component in the preparation and evaluation of projects within the scope of the National Investment System of Chile (SNI)). The methodology used was quantifiable qualitative. The research considered the analysis of methodologies and information requirements for the preparation and evaluation of ex ante projects, the review of models in ex post projects, the design of a methodology for the development of a model and the application in a project (case) , which was done through interviews, observations and analysis of documents. The results obtained show that the methodologies for the preparation and evaluation of public (social) investment projects, unlike private projects, do not consider an information module on the organization for the operation, nor do the sectorial information requirements . However, the projects evaluated ex post reveal the importance and usefulness of having an ex ante model for its implementation and operation ex post. And based on a definition of content, a methodology was designed to develop a model that allows planning, monitoring and evaluation of an investment project.

Keywords: design and management, preparation and evaluation of projects, management model.

DISEÑO DE UN MODELO DE GESTIÓN EN LA PREPARACIÓN Y EVALUACIÓN DE PROYECTOS

Resumen. El presente artículo expone parte de los hallazgos de una investigación destinada a diseñar una metodología para la elaboración de un modelo de gestión (MdG), como componente básico en la preparación y evaluación de proyectos en el ámbito del Sistema Nacional de Inversiones de Chile (SNI). La metodología utilizada fue de tipo cualitativa cuantificable. La investigación consideró el análisis de metodologías y requisitos de información para la preparación y evaluación de proyectos ex ante, la revisión de modelos en proyectos ex post, el diseño de una metodología para la elaboración de un modelo y la aplicación en un proyecto (caso), lo cual se realizó a través de entrevistas, observaciones y análisis de documentos. Los resultados obtenidos dan cuenta que las metodologías para la preparación y evaluación de proyectos de inversión pública (sociales), a diferencia de los

proyectos privados, no consideran un módulo de información sobre la organización para la operación, así como tampoco los requisitos de información sectoriales. Sin embargo, los proyectos evaluados ex post revelan la importancia y utilidad de contar con un modelo ex ante para su puesta en marcha y operación ex post. Y a partir de una definición de contenidos, se diseñó una metodología para la elaboración de un modelo que permita la planificación, el seguimiento y la evaluación de un proyecto de inversión.

Palabras clave: diseño y gestión, preparación y evaluación de proyectos, modelo de gestión.

Introduction

Unlike private projects, which have an organizational information module for project operation, public projects lack such information, that is necessary for both ex ante and ex post evaluation. This is why the design of a methodology for the elaboration of a management system (hereafter MS) is proposed as a basic component in the preparation and evaluation of projects within the scope of the NIS (National Investment System).

Consequently, a methodology for the elaboration of a MS is created in order to correct the deficiencies in the design and management of projects. This implies: reviewing the existence of a management information module in the design and ex ante evaluation from a sample of projects; examining the practical application of a theoretical management model from a sample of projects; designing standard indicators for planning and controlling project management; and explaining the operational performance of projects (sample) according to a standard MS.

The findings show that the projects involved in the study, organize the operation of their regular activity considering guidelines that emerge from the Operational Unit responsible for its administration. However, having a formal MS in the pre-investment (ex ante) for its implementation (ex post) would have been a useful guide for its sustainability and proper functioning.

Therefore, the importance of incorporating a MS with its own methodology, contributes to complement the theory of project preparation and evaluation (from the NIS perspective). In practical terms, it represents a contribution to the project management in order to ensure proper functioning and provide the level of service for customers / beneficiaries (ex post).

The aforementioned allows us to conclude that the design of a methodology for the elaboration of a MS goes beyond the NIS, since its contents allow the elaboration of a logical framework matrix and a business model. Furthermore, having considered the application of the model in a typical project (nursery schools), contributes to correct the deficiencies observed in the design and management phases.

As a line of continuity in subsequent studies, within the "relevant objectives" of the Ministry of Social Development of Mexico (2019), there is an opportunity to promote continuous improvement in the system for evaluating social programs and investment initiatives, in order to strengthen their role as a relevant input in decision-making (p. 1).

And within the limitations, following the "strategic products" of the Ministry of Social Development (2019), we can find: the difficulty of introducing changes and implementing innovations to the set of rules; instructions and procedures that govern the public investment process; guiding the formulation, implementation and evaluation of investment initiatives; providing updated methodological instruments; training in matters of social evaluation of

projects; registration of investment initiatives in the integrated project bank and feedback to investment processes through ex post evaluation (p. 2).)

> As defined in UNINI (2018), in its text "introduction to projects":
>
> A project is an operation of study and innovation, and the result of that operation. We have to find the thing, service, product or result that is going to be useful, and to organize the actions in advance to achieve it. It is a human activity, whose aim is to achieve a previously established objective and with a defined timetable.
>
> In order to carry out a project in an optimal way, it is required to be able to fully meet its phases, which are design and management. The design phase corresponds to the methodological formulation in order to find the solution to the problem. Besides, the management phase consists of the execution, control and evaluation of the project results.
>
> What we do when we focus on the task of executing a project, is to look for the solution to a problem or need, which generates a conflict. This problem or need in turn affects certain people who want to solve this situation (p. 1-2)

On the other hand, the public investment projects that enter the NIS, follow the preparation and social evaluation of projects methodology that takes into account the problem (opportunity), diagnosis (market study), alternatives (technical study) and evaluation (costs and benefits to society valued in economic terms), and the module on "legal, institutional and organizational aspects" that affects the preparation (design), evaluation (operational costs) and the project management,, is omitted.

As a solution to the problem, the "design of an MS methodology that contributes to the efficiency of project design and management", is considered. The essential points are related to evidence (deficiencies) found in the projects ex-post evaluation (implementation) on what was planned in the ex-ante evaluation. In addition to the methodology, the presentation of projects to the NIS considers sectoral information requirements, which very few sectors mention, some as a "management plan" (without development). This is contrary to the preparation and private evaluation of projects, which considers a management information module (study on legal, institutional and organizational aspects).

The hypotheses (H) and objectives proposed are related to:

H1: Management information is a key module for project design and evaluation. Review the existence of a management information module in the design and ex ante evaluation of a sample of projects.

H2: The development of a MS represents a guide for project implementation. Examine the practical application of a theoretical management model from a sample of projects.

H3: The design of indicators facilitates project management planning and control. To design standard indicators for the planning and control of project management.

H4: The existence of an ex ante MS contributes to the good performance of the ex post project. Explain the operational performance of projects (sample) according to a standard MS.

Method

The methodology used was qualitative and quantifiable. The research considered the analysis of methodologies and information requirements for the preparation and evaluation of

ex ante projects; the review of models in ex post projects; the design of a methodology for the development of a model and the application in a project (case). This was carried out through interviews, observations and analysis of documents.

By means of a qualitative methodology, the measurement and quantification of the data constitutes the procedure used to achieve objectivity in the knowledge process. The search for objectivity and quantification is oriented towards establishing averages based on the study of the characteristics of a large number of subjects. From there, explanatory laws of events are deduced in terms of pointing out causal relationships between social events. The explanations provided are contrasted with current reality so that their agreement with it defines the veracity and objectivity of the knowledge obtained.

According to the results obtained from the "Methodological outline of the research" in UNINI (2018), the "critical" variables identified in the methodology correspond to the following relationship (see table 1):

Table 1

Critical variables identified in the problem

Variable	Methodological criteria	Type	Way of performance	Effect	Methodological phase (relationship)
Insufficient methodological information for the project design (preparation)	Independent ("Deficiency in the projects design and management" - Dependent)	Quantifiable qualitative	Methodologies do not include an analysis of the project organization (management)	Deficiencies in the project design and management	Review of the existence of an information module on the organization as a methodology for the project preparation and evaluation
Insufficient information requirements to complete the project file	Independent ("Deficiency in the projects design and management" - Dependent)	Quantifiable qualitative	Information requirements do not include a project organization (management) model	Deficiencies in the project design and management	Review of the existence of management models as information requirements as part of the project file
No (theoretical) guidance to guide project management in practical terms	Independent ("Deficiency in the projects design and management" - Dependent)	Quantifiable qualitative	"Management model" type guidance has no practical application in those projects that do consider it in theory	Deficiencies in the project design and management	Review of the (practical) application of a (theoretical) management model in "model" projects

Support tools do not consider guidelines for project planning and management control	Independent ("Deficiency in the projects design and management" - Dependent)	Quantifiable qualitative	Absence of indicators makes project planning and management control more difficult	Deficiencies in the project design and management	Design of "standard" indicators for the project management planning and control.

Note: Source: own design based on the instructions given by UNINI (2018).

Work Plan

The development of the research was carried out according to a work plan, which is related to the following phases (F), activities (n°) and months (see table 2):

Table 2

Gantt Chart "Research Calendar"

Gantt Chart (Phases, Activities and Months)												
F1	Review of the existence of an information module on the organization as a methodology for the project preparation and evaluation											
n°	Activities description	1	2	3	4	5	6	7	8	9	10	11	12
1	Identification of project preparation and evaluation methodologies that take into account information about the project organization (management)												
2	(Short) description of the project preparation and evaluation methodologies that take into account information about the project organization (management).												
3	Review of the organizational information (management) for project preparation												
4	Identification of the most frequent errors in project preparation												
5	Review of the organizational information (management) for project evaluation												
6	Identification of the most frequent errors in project evaluation												
7	Determination of the existence (or not) of organizational (management) information in the projects preparation and evaluation												

F2	Review of the existence of management models as information requirements as part of the project file	
1	Identification of information requirements for projects that take into account organizational (management) information of the project	
2	(Short) description of the information requirements for projects that take into account organizational (management) information of the project	
3	Review of the organizational (management) information requirement for project preparation	
4	Identification of the most frequent errors in project preparation	
5	Review of the organizational information (management) requirement for project evaluation	
6	Identification of the most frequent errors in project evaluation	
7	Determination of the existence (or not) of organizational (management) information of projects in the information requirements	
F3	Review of the (practical) application of a (theoretical) MS in "model" projects	
1	Identification of projects that have completed the ex-post evaluation or have been visited in the field	
2	Description of the main deviations and results obtained	
3	Review of organizational (management) information in the ex-post evaluation	
4	Description of ex-post evaluation findings	
5	Review of organizational (management) information in the ex-ante evaluation	
6	Description of the lessons learned for the ex-ante evaluation	
7	Recognizing the usefulness (or not) of a theoretical MS in practical terms	
F4	Design of "standard" indicators for the project management planning and control.	

1	Description of the main contents found about the projects (ex-ante) organization (management)	
2	Description of the main contents on the projects' organization (management) learned in the ex-post evaluation	
3	Relationship of ex-ante and ex-post content with the theory of project organization	
4	Review of methods about project management planning and control	
5	Definition of a model that brings together content and management indicators	
6	Testing of the model from a pilot project	
7	Conclusion about the proposed MS design	

Note: Source: own design based on the instructions given by UNINI (2018).

Regarding the research questions, objectives and hypotheses, the work plan is concatenated through the following relationship (see table 3):

Table 3

Questions, objectives, and hypothesis relationship with the work plan

Questions	Objectives	Hypothesis	Work plan
1. Is a management information module identified and analyzed in the project ex-ante design and evaluation?	1. Review the existence of a management information module in the design and ex ante evaluation of a sample of projects.	1. H1: Management information is a key module for project design and evaluation.	F1: Review of the existence of an information module on the organization as a methodology for the project preparation and evaluation F2: Review of the existence of management models as information requirements as part of the project file
2. Is there a theoretical and practical application of a MS project?	2. Examine the practical application of a theoretical management model	2. H2: The development of a MS represents a guide for	F3: Review of the (practical) application of a (theoretical) MS in "model" projects

	from a sample of projects.	project implementation.	
3. Are indicators or variables established for the project management planning and control?	3. To design standard indicators for the project management planning and control.	3. H3: The design of indicators facilitates project management planning and control .	F4: Design of "standard" indicators for the project management planning and control.
4. Does the existence of a standard management model facilitate effective performance of the project's operational unit?	4. Explain the operational performance of projects (sample) according to a standard MS.	4. H4: The existence of an ex ante MS contributes to the good performance of the ex post project.	F3: Review of the (practical) application of a (theoretical) MS in "model" projects

Note: *Source: own design based on the project development.*

Results

The NIS is the technical institutional and legal framework within which the public investment process takes place. It is made up of the public investment policy; the institutions that participate in the process; the internal and inter-institutional administrative channels; the laws, regulations, orders, etc., that govern it; the methodological tools to identify, formulate, evaluate, execute, administer, follow up and operate projects; the technical staff and the public investment decision-making process.

The NIS includes the states of pre-investment, investment and operation, looking for their rationality in order to maintain a continuous flow of projects with different degrees of maturity.

A public investment project responds to a decision on the use of resources with one or more of the objectives to increase, maintain or improve the production of goods or the provision of services.

The path of any project is generally materialized in a physical work, which constitutes its life cycle. There are three successive stages: pre-investment, investment and operation. In the first one, the project is prepared and evaluated in order to determine if it is convenient to execute it. In the second one, in the case it is carried out, the design or detailed engineering project is done, as well as the work construction of the work. Finally, in the operation stage, the finished work is started, according to what was projected, which will generate during its useful life the net benefits estimated in the pre-investment stage.

Figure 1 shows the phases, stages and timing of project preparation and evaluation according to its life cycle.

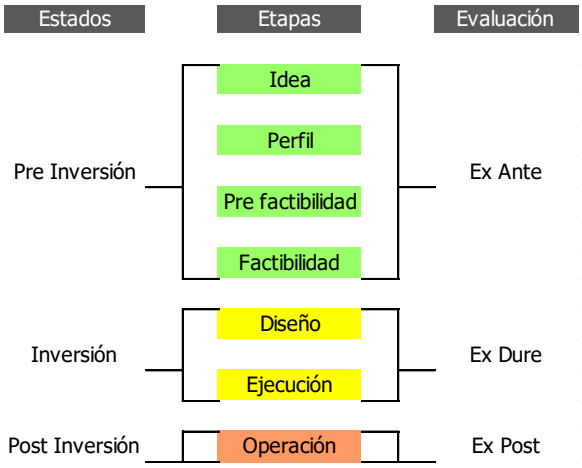

Figure 1. Project Preparation and Evaluation according to its Life Cycle

Note: Source: own design based on literature review.

In this regard, it is advisable to first consider the analysis in purely technical terms and then to move on to the economic terms. Both analyses make possible to qualify the project alternatives or options and, as a result, to choose the one that is most suitable according to the existing conditions.

In order to determine the socio-economic profitability of a project, the following elements are required: estimates of investment amounts and operating costs, an investment schedule and approximate figures for the income that the project would generate during its useful life. With such background, the project is evaluated economically, determining the degree of goodness of each of its alternatives selected in the profile stage, to compare and sort them according to their profitability. Therefore, it is established which ones deserve a more in-depth study and which ones are discarded.

In this regard, Table 4 shows a comparative table about the projects preparation and evaluation according to their purpose: private and social. There is a close relationship in both approaches (private and social): the opportunity and the problem, the market study and the diagnosis, the technical, legal, institutional, organizational study and alternatives, and the private-financial and socio-economic evaluation. In both cases, the private and social evaluation, collects the income information and market study benefits and diagnosis respectively, while the expenditures and costs of the technical, legal, institutional, organizational study and the alternatives respectively. It should be noted that despite the importance of the organizational study (MS) for the preparation and the evaluation of the project for its operational sustainability, it is only mentioned in the private approach.

Table 4

Preparación y Evaluación de Proyectos según su Finalidad (cuadro comparativo)

	Private project		Social project	
	Information module	Contents	Information module	Contents
Project preparation	Summary and conclusions	Business opportunity	Summary and conclusions	Problem Identification
	Market study	Demand analysis	Diagnosis of the present situation	Area of study and influence
		Supply analysis		Target population identification
		Trade system analysis		Demand, supply and deficit
	Technical study	Size, productive process, location	Alternatives identification	Optimization of the present situation
		Works, supplies, investments and production		Configuration of alternatives
	Legal, institutional and **organizational** aspects	Legal framework, institutional analysis, **organization**		Size, technology and location
Project evaluation	Private and financial evaluation	Estimation of income	Socio-economic evaluation	Estimation of benefits
		Estimation of expenditure		Estimation of cost
		Cash flow, indicators of profitability (NPV, IRR)		Net social profits flows, indicators of cost-benefit or cost-efficiency
	Financial study	Alternatives to financing, financial instruments		Sensitivity analysis

Note: Source: own design based on literature review.

According to the results obtained from the application (practice) review of a MS (theoretical) in model projects, it is possible to say that this model represents a guide for launching and operation. In addition, the existence of an ex ante MS contributes to the good

performance of the ex post project. This can be illustrated in Figure 2, where the role of the MS in the design, evaluation and sustainability of the project (setting in progress) is represented.

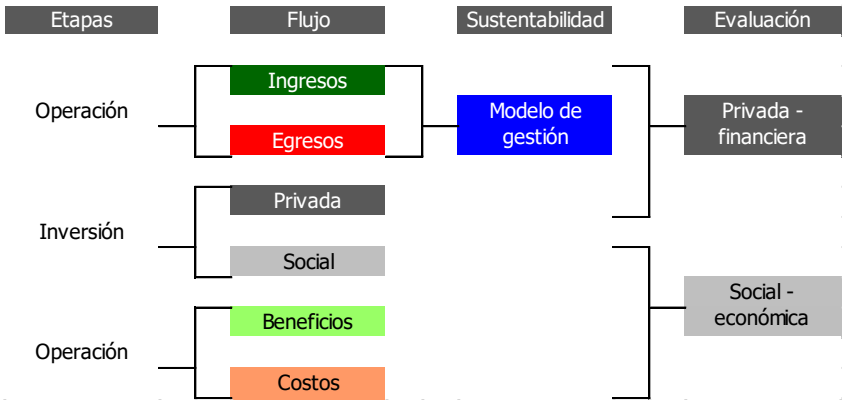

Figure 2. MS for the project design, evaluation and sustainability

Note: Source: own design based on the data review and the result obtained

Unlike private project evaluation, whose indicators, criteria and results are based on the income and expenditure projected over time, regarding investment and operation, updated to the present value (cash flows). On the other hand, social evaluation does so on the basis of benefits and costs, taking into account the externalities, the adjustment of shadow prices and the omission of taxes and subsidies (net social benefit flow). The MS, explained in some way in the private evaluation within the module on legal, institutional and organizational aspects for NIS projects, is equally relevant when it comes to providing guarantees on financial sustainability, that is to say, knowing a priori (ex ante) what level of organization and income is expected in order to respond to financial commitments important to ensure the project operation, by the managing body.

Management information (and errors) in: project preparation-evaluation methodologies and information requirements depending on the sector.

Together, Figure 3 shows the Management (nº) Information (and errors) found in the project preparation and evaluation and the information requirements by sector. In general terms, it can be seen that unlike private projects, where there is a module of information on legal, institutional and organizational aspects, both in the methodologies of project preparation and evaluation and in the information requirements for design and execution, the organization for operation (management) is disjointed and not very uniform in each of the economic sectors of investment.

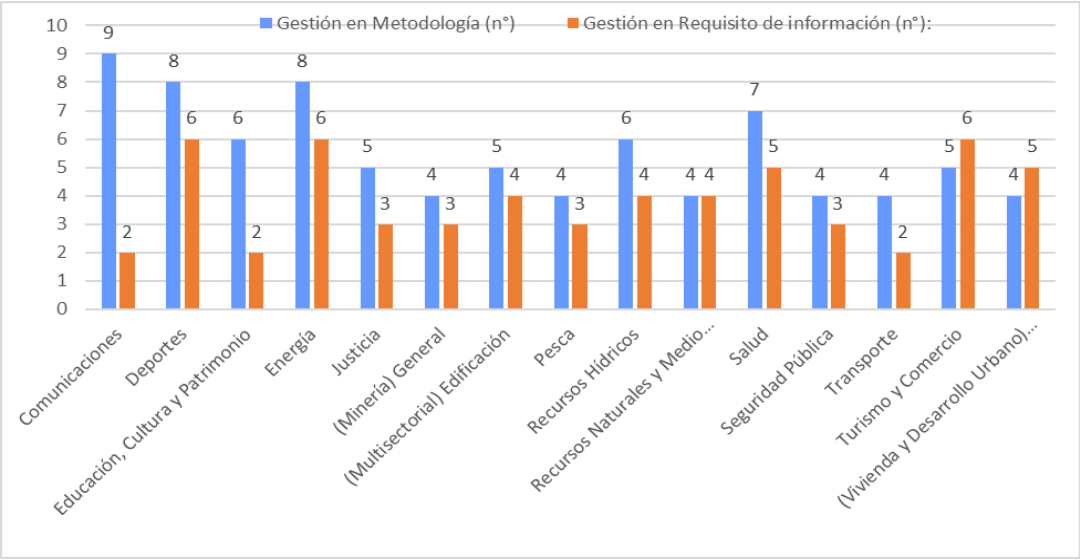

Figure 3. Management (nº) information (and errors) in project preparation-evaluation methodologies and information requirements depending on the sector

Note: Source: own design based on the projects preparation-evaluation and design-execution of each section

Figure 4 shows the relationship between management (rating) information (and errors) found in project preparation-evaluation methodologies and information requirements by sector (ex-ante). The results correspond to what is expected: the higher the rating (n°) of Information (and errors) in the methodologies, the higher the rating in the information requirements. There is an average degree of association between the variables, 44% measured by the statistical correlation coefficient "r". And under the assumption of a normal performance of the variables, 20% of the information found is explained by the errors found, measured by the statistical coefficient of determination "R2". The other 80% of the information found in the information requirements is due to other reasons (different from the methodological ones).

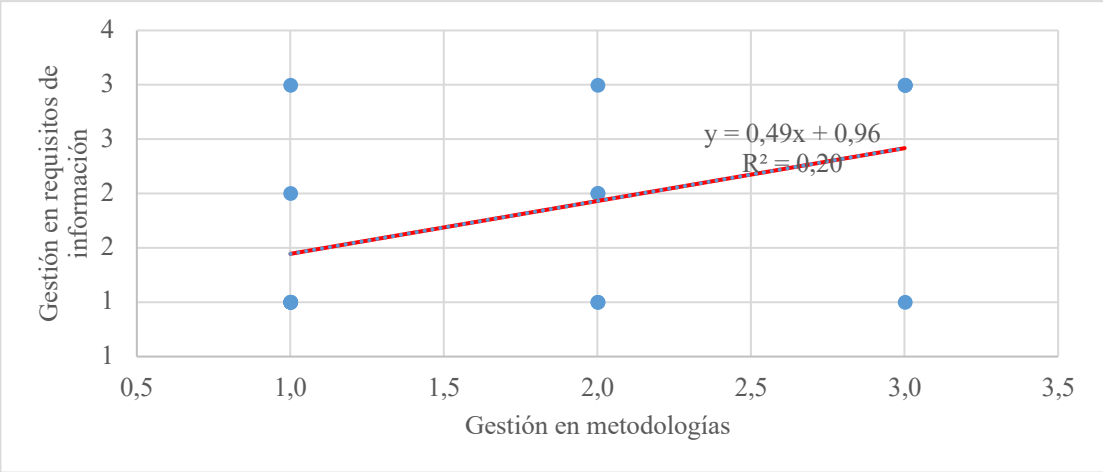

Figure 4. Relationship between management information (and errors) in project preparation-evaluation methodologies and information requirements depending on the sector

Note: Source: own design based on the projects preparation-evaluation and information requirements of each section

Development of an MS from ex-ante and ex-post evaluation

According to the review of literature, previous research and results of the investigation, a relevant methodology is designed for the elaboration of a MS; for the organization of the project operation, with a series of modules and contents, applied particularly to the NIS projects, in its design (architecture and engineering) and execution (construction) stages. And in general to all investment projects, which have a "compact" information module, and in the cases where other objectives are also sought, such as project planning, monitoring and evaluation for their management control, or for the design and innovation of a new business, by means of a model, are part of the results obtained.

Table 5 below summarizes what has been explained above, regarding the business model itself, considering the chapters and information modules, sections and contents, required according to the project investment, that is to say, design or execution. In addition, as a contribution to other instruments associated with control and business, the item (nº) related to the project logical framework matrix for management control is also indicated, as well as the business model, respectively.

Table 5

Information and contents modules for the elaboration of a MS

Chapter	Information modules	Section	Contents	Stage	MC	BM
1	Project management scope	1.1	Identification of the Unit in charge of its administration	Design		
		1.2	Management (in operation) scope and limitations	Design		

		1.3	Description of the infrastructure and equipment Implementation	Execution		
		1.4	Use and functionality description	Execution		
2	Management quality	2.1	Value (benefits, solution, satisfaction) proposition	Design		1
		2.2	Objectives: purpose and products (goods and services)	Design	1	
		2.3	Indicators, means and assumptions	Execution	2	
		2.4	Activities and key responsibles (in the operation)	Execution	3	6
3	Management organization	3.1	Organization model	Design		
		3.2	Identification of key personnel, positions and functions	Design		
		3.3	Beneficiaries (users), relations (personal?) and channels (web?)	Execution		2, 3, 4
		3.4	Alliances and key partners	Execution		8
4	Management resources	4.1	Description of resources for operation (personnel, consumer goods and services)	Design		7
		4.2	Management resources description	Design		
		4.3	Operation and maintenance commitments (quantification)	Execution		
5	Management income statement	5.1	Income sources	Design		5
		5.2	Costs structure	Design	4	9
		5.3	Cash flow (in "regular" operation)	Execution		
6	Risk management	6.1	Timeline of key activities (in operation)	Design	5	
		6.2	Identification of unfavorable scenarios (in the operation)	Execution		
		6.3	Identification of proactive or preventive actions	Execution	6	

Note: Source: own design based on literature review and on the research results.

Figure 5 below summarizes the above, in terms of the logical framework matrix, for a later evaluation and management control. The objectives developed as part of the MS are what the logical framework matrix recognizes as the first matrix column (1) of objectives through which the structure is solved analytically in terms of its intervention strategy. In addition, the

indicators, means and assumptions (2) can then be immediately organized into objectives, depending on their purpose and outputs. The indicators will serve to measure the project performance in its implementation and operation, in terms of the achievements sought by the project.

At the lower level, the activities and key responsibles (3), defined in the MS. Although they are not sufficiently disaggregated, since they are the main ones, but at least represent a first approximation to then define their valorization and the time foreseen for their realization, that is to say a budget (4) and a schedule of activities (5), which will allow the monitoring of the project and management control. In addition, the table is complemented by proactive and preventive actions (6), regarding the assumptions, critical success factors and contingency measures for unfavorable situations.

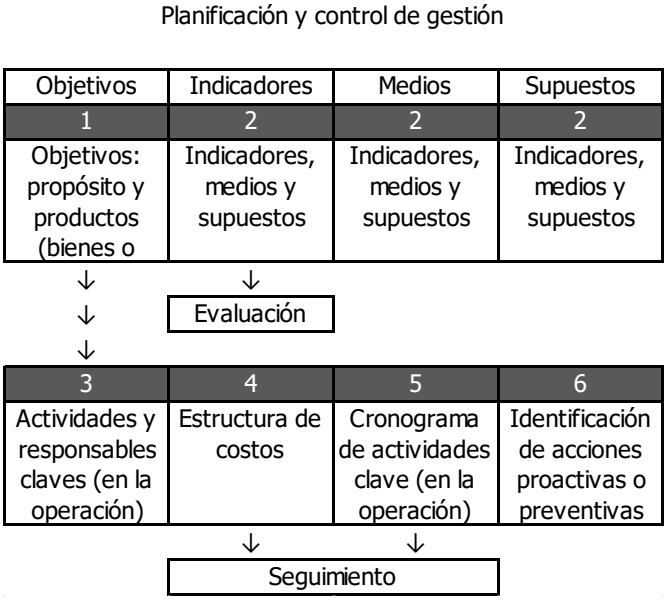

Figure 5. Information modules for the elaboration of a logical framework matrix

Note: Source: own design based on literature review and on the research results.

Figure 6 below summarizes the above, in terms of the business model. The value proposal (1), which considers benefits to give satisfaction to users and solution to the problem. Besides, the business model recognizes it as "supply". On the other hand, the benefits, relationships and channels (1, 2 and 3) correspond to the "customer" quadrant. In addition, the activities (6), resources (7) and alliances (8) is what is organized in the infrastructure quadrant. And finally the economic quadrant, made up of the variables (contents) income (5) and costs (9).

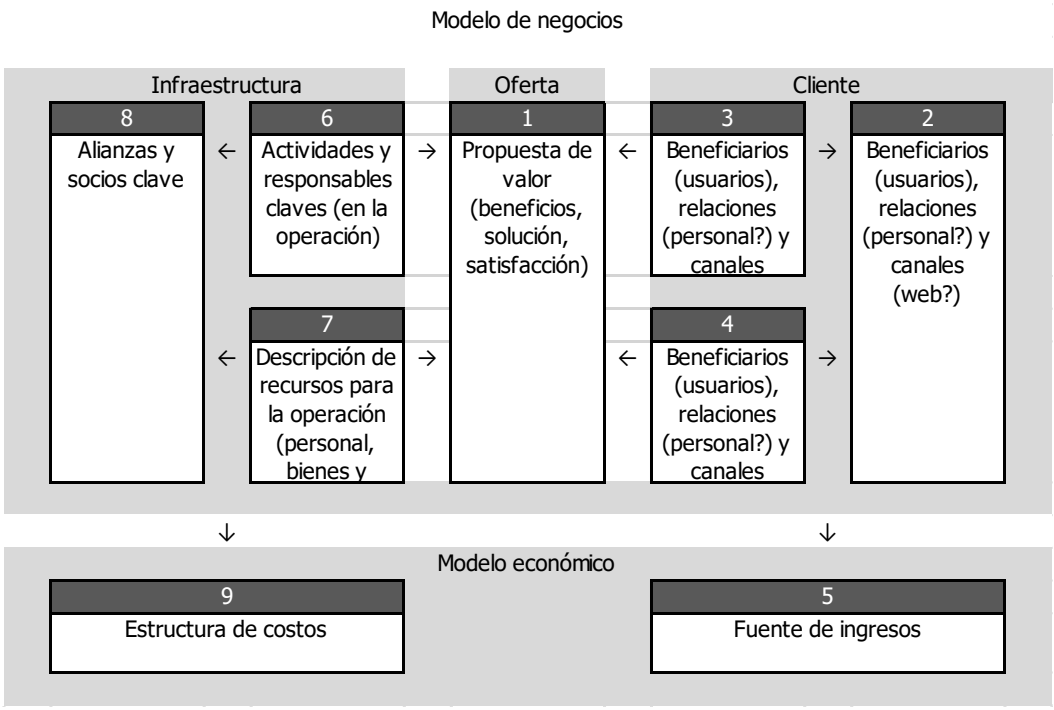

Figure 6. Information modules for the development of a business model

Note: Source: own design based on literature review and on the research results.

Discussion and conclusions

Application of the methodology for the elaboration of a MS in a model project

In order to choose a project where the MS could be calibrated (tested), a representative "exemplary" project in the field of NIS was used. To this end, a project recently initiated by the Ministry of Social Development (2019) was taken into consideration. It is called the "Bulletin of Good Practices in the Formulation of Investment Projects". Its first copy considered eight nursery schools among 16 representative projects in the country in the education sector.

> The Education Sector is made up of various sub-sectors. However, in this edition, you will be able to consult good practices used in the formulation and evaluation of Preschool Education projects, which play a main role in the early stimulation of the population, and in Basic and Secondary Education. This not only provide continuity to the previous one, but also tries to ensure that the process of transmitting knowledge to students is carried out in an optimal manner. The greatest difficulty of these initiatives does not lie in the alternatives' evaluation, but in the project formulation. This is mainly evident when estimating the area of influence, defining the population and calculating the deficit that justifies the intervention. Nevertheless, it is also possible to consult in this edition some good practices referred to the alternatives' evaluation, such as the measurement of relocation costs, the development of management models that determine more accurately the costs, or the analysis of possible locations. The objective of this publication is to contribute to improve the education projects formulation, in the above-mentioned sub-sectors, by those institutions that present initiatives to the S.N.I., through the good practices stated by the analysts of each region in their projects, which can be consulted by the formulators (p. 2)

In this sense, taking advantage of the recent construction and implementation (2018-19) of two establishments "presidential goal" of the National Board of Kindergartens (JUNJI, Junta Nacional de Jardines Infantiles)[1], of Chile, it was determined to test the model in two projects: "Kindergarten Continente Blanco" and "Kindergarten Cumbres Patagónicas.

In this way, the information is elaborated in a logical and sequential way, and will be organized in six groups (information modules): Project management scope (M1), Quality of management (M2), Organization in management (M3), Management resources (M4), Management state of results (M5) and Risk management (M6).

Firstly, although the Project management scope (M1) is derived from the project preparation and evaluation at profile level, it is useful for the experts (JUNJI and Kindergarten) to formalize it in a document (MS) that allows the identification of the organization responsible for the operation of the project, its scope and limitations. This information (ex ante) does not present observations or divergences in the implementation (ex post).

Secondly, the Quality of management (m2) agree that to develop a good management, it is important to always have in mind the services (products) generated by the Kindergarten, in order to fulfill the needs of the educational community (kindergartens, establishment staff, parents and representatives), and consequently to solve the problem that gave rise to the investment project.

Thirdly, the Organization in the management (M3), although in the educational structures the roles are quite formal, in practice the culture and organizational atmosphere can mark a style in their actions. Therefore, having some procedures written set would facilitate the organization of work and relations with the various individuals involved in the project management. For the section "Alliances and key partners", no ex ante information was found. It is suggested to complement it with suppliers and contributing entities, such as: Regional Ministerial Secretariat of Education, Subsecretariat of Nursery Education, Superintendence of Education through the Intendancy of Nursery Education, JUNAEB, contractors and suppliers through the Public Procurement Law.

Fourthly, the management resources (M4) are fundamental in order to guarantee the financial sustainability of the project. Although the resources are contributed by the supporter (JUNJI) to the Kindergarten(s), through current transfers to cover the resources necessary for the project operation and maintenance, such as personnel expenses and consumer goods and services, these must be measured and valued. In the ex-post evaluation, the resources for maintenance correspond to the Regional Educational Spaces Construction and Maintenance Unit (Unidad de Construcción y Mantención de Espacios Educativos Regional), through a Maintenance Plan prepared based on the diagnosis of the premises, requesting annual resources that are authorized by the same institutional area at the central level, which are executed through maintenance service contracts subjected to the provisions of the Public Procurement Law and rendered according to institutional provisions.

Fifthly, we find the Management state of results (M5). The income is assumed to be equivalent to the inertial budget of regular operating expenses (Allocations through the Public Sector Budget Law). These are not identified, quantified or valued based on an income budget, for the construction of an operating cash flow. No evidence was found in the pre-investment (ex-ante evaluation). It is recommended to make an effort to identify scenarios with deficit or surplus.

[1]The Presidential Goal states "More Nursery Schools and Kindergartens for Chile", a program to increase coverage in nursery education as part of the Educational Reform, which will allow 70,000 new places to be installed in the first level of education.

Finally, for Risk Management (M6), no information was found in the pre-investment (ex-ante) and due to some negative situations presented in the launching and first year of operation, key activities, essential for success, have been missed. In addition, it has been necessary to act in a reactive way (instead of preventing) in case of an emergency. For this last part, the importance (and usefulness) of having some contingency (or emergency) fund to draw on in case of unfavorable scenarios, such as minor repairs and delays in payment of basic service providers, is recognized.

Conclusion

The findings show that the projects involved in the study, organize the operation of their regular activity considering guidelines that emerge from the Operational Unit responsible for its administration. However, having a formal MS in the pre-investment (ex ante) for its implementation (ex post) would have been a useful guide for its sustainability and proper functioning.

Therefore, the importance of incorporating a MS with its own methodology, contributes to complement the theory of project preparation and evaluation (from the NIS perspective). In practical terms, it represents a contribution to the project management in order to ensure proper functioning and provide the level of service for customers / beneficiaries (ex post).

The aforementioned allows us to conclude that the design of a methodology for the elaboration of a MS goes beyond the NIS, since its contents allow the elaboration of a logical framework matrix and a business model. Furthermore, having considered the application of the model in a model project (nursery schools), contributes to correct the deficiencies observed in the design and management phases.

Applying the model in a model project (kindergarten) that brings together content and management indicators, requires the design of a methodology that makes possible to foresee and document the way in which the operating unit (JUNJI) will carry out the project administration (organization for the operation), which makes possible, at the same time, to maintain its operation and financing over time (sustainability). To this end, a general information methodology (standard) is designed to be broad and flexible enough to represent reality and to be able to adapt to any project.

Although much of the information can be transferred in a "MS" document, the information that is absent is the one that is related to the ex post evaluation and management control. This is typified as "Indicators, means and assumptions" (this information is inherent to the logical framework matrix, method that is not required for the projects in the NIS). As a result of the ex-post evaluation, the following indicators for outputs were obtained:

- Educational service offered: 188 places (according to the project).
- Recruitment of staff: 33 staff members (1 director, 1 administrator, 7 classroom teachers, 21 technicians, 3 assistants).
- Facilities: 7 activity rooms, changing rooms, rooms of hygienic habits, playgrounds, multipurpose room, breastfeeding room, offices, kitchens, dining room, warehouses and toilets.
- Area built: 1.127 m2 built, received and delivered to the administrator.
- 33 female public workers hired.
- 142 nursery schools registered (until November 2019) (registration under new institutional arrangements).
- 7 activity rooms, multipurpose room, kitchen, dining room, warehouse and toilets
- 1.127 m2 built.
- Personnel recruitment and induction: JUNJI Personnel Management Vice president.

- Dissemination campaign to complete the registration according to the number of places: Educational Unit with the support of the Vice president of Communications and Citizenship JUNJI
- Construction of infrastructure and complementary works: Unit of Construction and Maintenance of Educational Spaces JUNJI
- Basic services facilities (water, electricity, gas): Unit of Construction and Maintenance of Educational Spaces JUNJI

In short, the lack of an information formal module the organization for the project operation, through the methodologies of project preparation and evaluation (ex ante) or, through the sectoral information requirements, justify the installation of a MS as a basic component for the project planning, monitoring and evaluation. These represent a guarantee for the financial sustainability of the operation, through the generation of goods and services and the obtaining of the economic-social benefits in the search for a response and satisfaction of the problem-solution.

References

Baca G. (2016). *Evaluación de proyectos*. (5º Ed.). México: McGraw-Hill

Casimiro H. (2017). *Modelo eficiente de gestión de proyectos para la evaluación, monitoreo y control de la inversión pública en el departamento*. Perú.

Contreras E. y Zaviezo L. (2012). *Inversión Pública: Desafíos del Sistema Nacional de Inversiones*. Santiago de Chile.

Díez-Silva H., Arboleda J. y Montes-Guerra M. (2011). *Seguimiento y control de proyectos en el sector público. Análisis preliminar del sistema de inversión estatal colombiano*. Colombia.

Dupuit J. (1844). *On the Measurement of the Utility of Public Works.* Annales des Dupuit.

Espinoza M. (1980). *Evaluación de Proyectos Sociales. Ministerio de Cultura y Deportes*. Costa Rica.

Espinoza A. (2000). *Metodología de evaluación ex ante de Programas Sociales. Serie: Material de Apoyo a la Planificación Social*. Documento de Trabajo Nº 4.

EVO (1997) *Evaluación: Una Herramienta de Gestión para Mejorar el Desempeño de los Proyectos*. Santiago de Chile: BID

Hernández R. (2014). *Metodología de la investigación*. México: McGraw-Hill

Harberger A. (1964). *The Measurement of Waste.* AER Project Evaluation.

Hicks J. (1939). The Foundations of Welfare Economics. *Economic Journal 49* (196), 696-712. doi:10.2307/2225023.

Instituto Latinoamericano y del Caribe de Planificación Económica y Social (2004). *Los sistemas nacionales de inversión pública en Centroamérica: marco teórico y análisis comparativo multivariado*. Santiago de Chile.

Jenkins G, Kuo CY, Harberger A. (2011). The Integrated Analysis of Investment Projects. In *Cost-Benefit Analysis for Investment Decisions*. Canadá: Queen's University.

Kaldor N. (1939). Welfare Propositions in Economics and Interpersonal Comparisons of Utility. *The Economic Journal 49* (195), 549-552. doi:10.2307/2224835.

Ministerio de Desarrollo Social (2019). *Boletín de buenas prácticas en formulación de proyectos de inversión*. Santiago de Chile.

Ministerio de Desarrollo Social (2019). *Objetivos relevantes y productos estratégicos.* Santiago de Chile.

Ministerio de Planificación y Cooperación (1993). *Preparación y Presentación de Proyectos de Inversión.* Santiago de Chile.

Monje C. (2011). *Metodología de la investigación cuantitativa y cualitativa guía didáctica*. Colombia: Universidad surcolombiana Facultad de ciencias sociales y humanas.

Morales C. (2010) *Colección Gerencia de Proyectos Formulación y Evaluación de Proyectos.* Medellín, Colombia: Unidad de Aprendizaje: Estudio Organizacional y Legal.

Oficina de Planeamiento y Presupuesto de la Presidencia del Uruguay (2014). *Guía para la formulación y evaluación de proyectos de inversión.* Uruguay.

Sapag N. y Sapag R. (2008). Preparación y evaluación de proyectos. (5º Ed.). México: McGraw-Hill

Universidad internacional Iberoamericana (2018). *Introducción a proyectos*. (Tesis Doctoral). México.

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PMBOK AND VALUE ANALYSIS IN CONSTRUCTION

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Abstract. Construction in the Ecuadorian economy accounts for 8.39% of the GDP, being the fourth sector in contributing to the country's production. The activities and items used are the same as those that have been managed in past decades, without generating any type of improvement or reengineering of the processes that are currently applied in other countries. The direct costs in the construction of projects have not changed and little has been developed by applying the current existing methodologies. The Value Analysis in Construction promotes its improvement and innovation, both in materials and processes, which generates substantial savings in the projects, maintaining optimal levels of quality. The PMBOK, a PMI tool that has its extension in construction, determines the standards that professionals must-have for the management of construction projects, applying knowledge, skills, tools, and techniques to meet project requirements. Both methodologies must be supplied to improve the costs and performance of the projects without affecting their quality. PMBOK and Construction Value Analysis must be mutually complementary to improve and optimize project planning and execution. The objective of this article is to determine how PMBOK and Construction Value Analysis complement each other to improve and optimize project planning and execution. Among the results, it stands out that the Analysis of Construction Value is a tool that the PMBOK must apply to optimize costs and time in the execution of projects, improving the processes that the PMBOK applies.

Keywords: PMBOK, Value, Cost, Profit.

EL PMBOK Y EL ANÁLISIS DE VALOR EN LA CONSTRUCCIÓN

Resumen La construcción en la economía ecuatoriana aporta con 8.39 % del PIB, siendo el cuarto sector en contribución a la producción del país. Las actividades y rubros que se utilizan son los mismos que se han manejado en décadas pasadas, sin generar algún tipo de mejoramiento o reingeniería de los procesos que en la actualidad se aplican en otros países. Los costos directos en la construcción de proyectos no han cambiado y poco se han desarrollado aplicando las actuales metodologías existentes. El Análisis de Valor en la Construcción promueve su mejoramiento e innovación, tanto en los materiales como en los procesos, lo cual genera ahorros sustanciales en los proyectos, manteniendo los niveles óptimos de calidad. El PMBOK, herramienta del PMI que tiene su extensión en la construcción, determina los estándares que los profesionales deben tener para la dirección de los proyectos constructivos, aplicando conocimientos, habilidades, herramientas y técnicas para cumplir con los requisitos del proyecto. Ambas metodologías deben suplirse para mejorar los costos y rendimientos de los proyectos sin afectar su calidad. El objetivo de este artículo es determinar como el PMBOK y el Análisis de Valor en la Construcción se complementan para mejorar y optimizar la planificación y ejecución de proyectos. Entre los resultados se destaca que el Análisis de Valor en la Construcción es una herramienta que debe aplicar el PMBOK para optimizar los costos y tiempos en la ejecución de proyectos, mejorando los procesos que el PMBOK aplica.

Palabras clave: PMBOK, Valor, Costos, Beneficio.

Introduction

Since 2000, Ecuadorian construction companies have focused on having quality systems in the activities carried out in that company, having to specify the steps to be taken, which materials are going to be used, and which is the process to be followed. Over the years, these quality systems have incorporated higher standards to be met, promoting detailed studies of each activity, determining the existence of waste both in time and materials, the reason to implement Value Analysis of activities. In this way, the Value Analysis is a tool of continuous improvement that generates in the quality systems a substantial improvement in the costs' reduction.

As far as construction companies are concerned, they have implemented their own construction method for each activity/item, which has been improved over time thanks to the experience gained. According to Subramani, Jabasingh, Jayalakshmi (2014) [01] *Analysis of Cost Controlling In Construction Industries by Earned Value Method Using Primavera* [02], Value Analysis allows minimizing the costs of these processes. In most construction projects there is excess cost and time due to multiple factors. Using the Earned Value Method, which is a performance evaluation technique in the engineering industry, we can get the first indications of performance in the project to highlight the need for corrective action as appropriate. According to Bar (2012), 60% of innovation in construction companies is unplanned, and they can improve their competitiveness through cost optimization and innovation management as a business process.

Each project that is going to be executed is always analyzed from the point of view of the service that is going to be provided. The project must fulfill the objectives for which

it was planned, but, it is not analyzed how the costs can be optimized when they are executed.

Another tendency in the improvement of construction is due to the reduction of waste generated in each project, which is mainly due to the implementation of new laws of environmental protection, which forces companies to seek alternatives that can be made in the projects. This causes in some cases an increase in costs to meet the requirements requested (as an example, we see some asbestos waste whose disposal costs are extremely high).

Table 1

Costs tariffs Empresa Pública Metropolitana de Gestión Integral de Residuos Sólidos

SERVICE	UNIT OF MEASURE	RATE $ (WITHOUT VAT)
Disposal of common solid waste similar to domestic waste at the North Transfer Station	Tonne	26.43
Disposal of common solid waste similar to domestic waste at the South Transfer Station	Tonne	27.57
Final disposal of common solid waste that similar to domestic waste in the Sanitary Landfill.	Tonne	19.94
Final disposal of common solid waste similar to domestic waste in the Rumiñahui solid sanitary waste landfill.	Tonne	21.59
Final disposal of common solid waste similar to domestic waste in the sanitary waste landfill that does not come from the Metropolitan District of Quito, DMQ.	Tonne	18.74
Debris Disposal Daytime	m3	0.57
Debris Disposal Nighttime	m3	0.57
Disposal of Debris from the Quito Metro Project Daytime	m3	1.13
Disposal of Debris from the Quito Metro Project Nighttime	m3	1.45
Collection, transport, treatment and final disposal of health care waste (Infectious, Biological, and Sharps)	Kilogram	1.50
Treatment and final disposal of health care waste (Infectious, Biological, and Sharps) (Not including transport).	Kilogram	1.35

Note: Source: Quito Metropolitan Public Company for Integral Solid Waste Management

Most of these changes occur when there are problems in their execution. This forces us to innovate in the ways of doing things, reusing materials, and generating value for each of the activities.

The Project Management Institute (PMI) has the Guide to the Fundamentals of Project Management, which indicates that project management is the application of knowledge, skills, tools, and techniques to meet the project requirements. PMI develops the Standards for Project Management Professionals known as *Guide to the Project Management Body of Knowledge* (PMBOK).

The objective of this article is to see the similarities and differences that exist between the PMBOK and the Value-Based Analysis in Construction, how these guides can be used and how they benefit the project for its correct execution.

Method

What is Value Analysis? According to Calzeta (2012) p.11, "It is a system that a company can use in an organized way to improve the value of its products or services and, therefore, obtain a reduction in costs as an ultimate goal".

Concerning the Analysis of Value in Construction, the variations in cost that do not generate value in the items must be quantified, respecting the methodology that we will use for its analysis, maintaining the following guidelines:

1. The activities of the items that generate direct and indirect costs and expenses in projects shall be quantified, costing all the activities, materials, equipment, that compose the project's development. Besides, expense corresponds to all the other elements that are not costs. (Horngren, Datar, Rajan, 2012).

In planning a project, the most important part of meeting this need is to evaluate the budget you have to be able to execute it. Secondly, it must be evaluated whether the activity is a direct or indirect cost or expense, based on the concepts of accounting costs.

In project cost accounting, the criteria that the accountant and the cost engineer have about the concepts of cost, expense, direct or indirect, allows the Value Analysis in Construction to be adequately performed. In this case, the main thing is to prepare and information update for the cost engineer, so that he can combine accounting information with technical information. Like that, he has a clear vision of the concepts and how they will be used in the budget preparation.

Later, based on the knowledge acquired, he will prepare the discrimination of the activities according to their costs and thus we will be able to have in the first instance which are the processes, materials, equipment, and labor that do not generate value to the project itself.

2. Changing, creating, or modifying these elements that generate indirect costs and expenses and minimize or transform them into direct costs, depending on the total cost of each project.

Indirect costs and expenses refer to all economic expenditures to be made in the project that are not directly involved in the manufacture of the items. For example:

- In materials: office supplies, printer toner, printing paper in central offices, cleaning elements, light payments, water, telephone, printers, computers, scanner, etc.
- In labor, we have: payment of secretary, messenger, office driver, receptionist, general manager, financial manager, general accountant, employees of the accounting department, or any employee who performs work functions in the office that is not directly involved in the construction of the project.
- Equipment: Cars, trucks, scooters, furniture, desks, or chairs that are used in the main office, not the project.

When the indirect costs and expenses, which are necessary for the good management of the project, are analyzed, they are perceived as "bad expenses". This causes unnecessary economic expenses, produce increases in the project budgets without considering that they can diminish the utilities and, still worse, it can provoke not obtaining projects because of high budgets. In several projects, it is better to have offices in the project, based on the following parameters:

- To reduce the cost or expense for information transmission between the central offices and the project office.
- Decrease the equipment needed to carry and bring in information and data for project advancement.
- Manage schedules, programs, plans, and management between the project and the command departments in a more appropriate way.
- Minimize the use of project and office personnel who can technically perform indirect work, for example, the use of cleaning personnel, which is only used at one point and not two.
- Occupational health and safety equipment that is mandatory in the legal bodies of each country, but only at one point of execution.
- Application of environmental management systems between the project and its central administration.
- Reduction of fuel, lubricants, mobilization expenses of all departments that do not work directly in the physical manufacturing of the project. As an example, we have a financial department, accounting.
- In the management of human resources, it is required to provide food to the project's work teams as well as the administrative area. This can be improved with the installation of a central dining room for all, which allows managing the food with the reduction of travel times and expenses that this entails. In addition to the shadow price that is part of the indirect costs involved, such as electricity, water, etc.

In the course of the general evaluation of indirect costs and expenses, it should be clearly agreed upon and discriminated according to the concepts, which and where we should locate each of the disbursements and their relation to the budget.

3. Analyze, reformulate, or innovate processes for the direct costs and expenses of each activity to reduce the direct cost of the item.

Innovate, create, change, or modify the activities, materials for others that generate value in the process. Value is a very wide concept but settled in the construction, they are elements that will remain in the project, in the time that they are used to create the project and that is necessarily managed for the construction. In several projects, based on the acquired experience, processes have been used repetitively without looking for modifications in it to generate value. Examples of this are wall plastering, construction of paved roads, construction of sewage inspection wells. Besides, direct costs can be classified according to their function. These can be materials, labor, and equipment.

In materials, several types can be used to make the same item. For example, the manufacture of concrete is known as a mixture of cement, gravel, sand, and water. Mechanical means are used for its manufacture, but if we want to give color to the concrete, most builders paint it whenever it is necessary. As an example, we have the signaling of curbs and sidewalks. Other easy and durable ways are to place dyes in the manufacture of concrete, which will give the necessary tone. Apparently, the initial cost will be increased by the dye, more in the course of the life, by not using additional paint, the replacement costs decrease giving as a final result the increase of value in the final product. In this sense, having several types of materials that can be used according to the criteria generated by the cost and study engineer together, causes a substantial increase in the generation of value in the constructions.

Regarding the labor, to carry out an activity that belongs to the item, it is necessary to use direct labor costs that do not generate value. For example, the use of personnel in the project to transport the input or raw material does not intervene in the creation of the value of that item. On the contrary, it is paid to transport raw material without the product having been elaborated yet. That is to say, to carry out activities that do not generate value, but you have the expense of labor without yet making the development of the item in the forms corresponding to the budget.

In equipment, something similar is analyzed: transporting the project generates direct costs, which have to be disbursed and are not yet part of the value chain of the final product. As an example, machinery is imported from another country, assembled and put into operation, generating expenses that are not yet being recovered in their production.

In the influence of the direct costs and expenses of equipment, there is the use of machinery for a few hours during the day. On many occasions, it is a waste of machinery to have them working two hours a day, with the handling of 20% of capacity. This does not allow to recover the investment done. It can be worse, as it can be generated utility in the same one. It is these failures in planning, that are not carried out in the project schedule, with equipment that has no versatility and spends little time in production.

4. Determine the performance of each activity and its direct influence on each item, to prepare schedules and graphic networks for the execution of each project.

When planning a project, regarding the time needed for its construction, no real yields are used for its analysis nor technological tools that can be managed for its measurement. They are planned in "assumptions" that someone once studied and determined those values without analyzing the processes used in the manufacture of the item. They were dedicated to counting totals of times in the construction of the item and with calculations of the average, they determined the necessary time by work team in the

unit of the executed item. In the end, no detailed study is made of "how" the activities should be done, with which teams, what skills the workers should have, what the specifications of the work center are, what the learning curve to be used is, and what the time needed to execute the activity is. It neither analyze what the requirements are in the case of lack of personnel or unscheduled activities in its execution. All this reflects a lack of planning and consequently increased gaps in the time and extraordinary costs of the project.

Regarding the equipment that also has influence in the cost by its relation with the time, the costs depending on the processes and yields of the activity are not analyzed. These are values that the manufacturer or some professional made under certain "ideal" characteristics that in the construction of each project are not equal. For example, the yields of excavation machinery in clayey soils can be much higher than in rocky soils, but if the rock is soft it can be higher than in a moisture-saturated (slippery) clay, which totally changes the cost and expense conditions.

When applying general knowledge of yields, it is not taken into account that over time, increases or decreases in yields are generated depending on several factors: The learning curve of the workplace improves the performance over time. Besides, something very peculiar is that when they are already within the expected standards, the last working day, usually Friday, generate higher yields than a Monday. It can also influence the feelings in the generation of higher yields. As an example, is that at Christmas or new year, there is an increase in work performance. People enter an environment of joy and tranquility. Otherwise, in the early days of the year, it decreases.

Regarding the equipment, apart from being directly manipulated by the emotional state that the operator is in, the equipment in spring, autumn or summer has much higher performance than in winter, due to the climatic conditions that affect it, as well as subrogating components of the type of work that they do. As an example, it is not the same to make concrete in winter than in spring, because the temperature of fresh concrete must be between 14 and 22 degrees centigrade for its manufacture, handling, and installation. In spring, if you can have it, but in winter you must heat the water, protect the aggregates from low temperatures and acclimatize the equipment so that it does not lose the thermal "transmittance" of the concrete. Like the labor, it will not have at any time the same performance in winter as in summer, autumn, or spring.

Other elements that directly affect performance are the age of the people and the equipment. The ages between 20 and 50 years keep the same performance in ideal conditions. Depending on the activity, older than this age, generate a decrease in performance, and they are less careful in their execution, which generates losses of time and therefore costs. Factors such as sex are also an influence on certain activities. As an example, for projects with physical effort activities, more female people are needed to equalize the performance of the male working group (transport of cement bags).

On the equipment, to determine its performance without making an analysis of the performance of the machines regarding their maintenance, return on investment, and the number of hours, they should be working in order not to incur unnecessary expenses. As an example, the use of paving equipment, the critical point in its use depends on the asphalt plant, because if it is of very low productivity, the installation and compacting equipment

decrease its performance. Having such low yields, costs cannot be equated with expenses and losses will occur.

There will always be innovative ways that can generate an increase in performance, decrease downtime, decrease expenses, costs, and therefore an increase in project profits that can generate as an alternative reinvestment in the same, to position it and decrease costs. As an example, we have that the savings generated in the manufacture of the plaster in buildings can be reused in other items that better position the project. As an example, we find the improvement in elevators that have a higher cost of manufacture but decrease their maintenance costs and transfer, which in the end are rewarded with higher sales of future projects and profits technically calculated.

Based on these examples, it should be noted that the calculation of yields does directly affect unit prices and therefore the project budget.

According to Espejo, Véliz (2013), the biggest problem with projects is that they are not achieving the efficiency and effectiveness planned for them. It is worse if we talk about construction projects: most of the problems encountered in their execution are due to a lack of planning.

In 2003, the Project Management Institute (PMI) published for the first time the *Construction Extension to the PMBOK Guide Third Edition*. In its first edition, it takes the first steps to implement a Methodology in the Construction sector, making a second edition in 2007 and the third edition that was published in September 2016. The extension of the PMBOK Guide in the construction sector seeks to improve the efficiency and effectiveness of construction management. The companies focus their efforts on the management and execution of projects, seeking on-site best practices to carry out the activity.

To use this methodology, it is necessary to start from the basic concept, which "procedures" must be followed for the realization of a purpose. In the case of construction, we have the determination of the strategic plan that gives the best path for the realization of the project. In other words, to create a procedure to identify, quantify, restructure, innovate, and calculate the activities and items of a construction project that substantially improves budgets and execution times.

The PMBOK guide is a way to carry out the execution of a project, but it is not strictly mandatory. As its name indicates, it is a guide that must be applied with good judgment. The PMBOK extension for construction, *Construction Extension to the PMBOK Guide* (2016), being a tool of the PMBOK, focuses directly on the construction of the following parameters to follow:

- Project records for cost estimates and budgets.
- Occupational health and safety management focused on processes to be followed to avoid work accidents.
- Environmental Management on guidelines for compliance with laws regarding the environment.
- Quality control management including inspections.
- Contract administration, financial management focused on the administration and control of economic resources.

- Management of subcontractors and suppliers.
- Change order and complaint management which are steps to follow to decrease or eliminate construction claims or complaints.

Technology has a direct influence on project communication, construction capacity, project control, and progress, to develop growth in the market. For a project to be successful according to the PMBOK the project team must:

- Determine the appropriate processes to achieve the project objectives.
- Have adequate communication in the project team.
- Meet requirements to satisfy customer needs and expectations.
- Comply with the scope, schedule, budget, quality, resources, and risk to obtain the expected result.

The PMBOK guide exclusively describes the processes that must be followed by the project management and execution, grouping them in 5 categories known as Project Management Processes groups or process groups:

- Start-up process group, which define the processes needed to start the project.
- Planning group. They define the processes needed to meet the scope, objectives, and course of action to develop the project.
- Execution group. Processes that must be carried out to execute the project planning, fulfilling all the requirements and specifications.
- Monitoring and control groups. Processes to review, track, and regulate the progress and performance of the project by identifying areas that require adjustments and changes.
- Closing process group. Processes to finalize all group and project activities.

The processes identified in the PMBOK guide are grouped into 10 knowledge areas differentiated into sets of concepts, terms, and activities, which are:

Value Engineering in the PMBOK Construction Extension. In planning management, it is used before finalizing the design to ensure the best value for the owner, in which you can explore possible competitive advantages in Construction with teams to "meet the functional needs of users". The schedule must be included to define resources, cost burden, and performance over time, having a plan to measure actual progress in both physical and time quantities. The value analysis is centralized on the user needs but not applied to budgets.

In the management of project execution, it aims to reduce the costs and duration of the project, with integrated change requests for project improvements, identifying which set of alternatives achieves the objectives. Life cycle cost analysis, value engineering, and constructability are planned in the project scope to compare implementation alternatives giving the highest security to all stakeholders minimizing social and environmental impact, time, and cost. It is already applied in the direct execution of the project, looking for alternatives in situ.

The PMBOK guide allows us to identify which sets of alternatives reach the objectives and requirements of the project minimizing the social and environmental impact, time, and cost, including logistics, materials, transportation, machinery, labor, and all the elements involved in the execution of the project. The management of the schedule involves the complex analysis of all those involved in the project: owner, contractor, subcontractors, suppliers, inspectors, equipment, procurement of materials, duration to be fully met, work schedules, performance, monitoring of all those involved to shape the projects to satisfaction.

The most widely used tool in the schedule is the critical path method (CPM), which requires all those involved to comply with the dates indicated, under penalty of failure to meet deadlines and delays in the completion of the project. In the use of the CPM method, it is possible to economically evaluate the resources needed for each activity, the percentage of progress in each item and its cost accumulation in the activities. It is necessary to take into account the time gaps produced by several factors. Among them, we find: climate conditions, environmental regulations, public or private restrictions, social impacts, permits, approvals, and rights.

The structure of the jobs must cover the scope of the project including all the requirements necessary to meet the time and cost, integrating all those involved in the process. The more detailed the breakdown and the larger the components are, the more unmanageable they can become, especially if activities are to be quantified in hours or minutes.

As with resources such as materials and equipment, a level of detail that is not very thorough must be maintained. This can lead to very high and unnecessary control costs and loss of time and money.

Estimates of the project duration depend on the availability of economic resources when the cash flow is representative. For example, the use of concrete that is relatively expensive and its planning depends on the existing cash flow. There should be a clear sequence of activities including all the project's own and external actions with a breakdown of the work structure, taking into account external factors such as subcontractor activities, equipment maintenance, holidays, weather, changes, etc.

Having time slots for the items in execution allows that the activities can be moved to the beginning of the foreseen date, to the middle of the activity (not recommended because of its high cost in stopping and starting again) or to the end of the activity. This has the purpose of being able to minimize the number of workers on certain dates.

As an example, we analyze the provision and placement of aluminum doors and the placement and provision of aluminum windows. If the first activity has 15 working days of execution with 3 days of clearance calculated in the Pert - CPM network and on the same dates the second activity is carried out with a duration of 3 days and clearance of 2 days, it is possible to modify the start of each activity to reduce the number of workers and equipment on those dates:

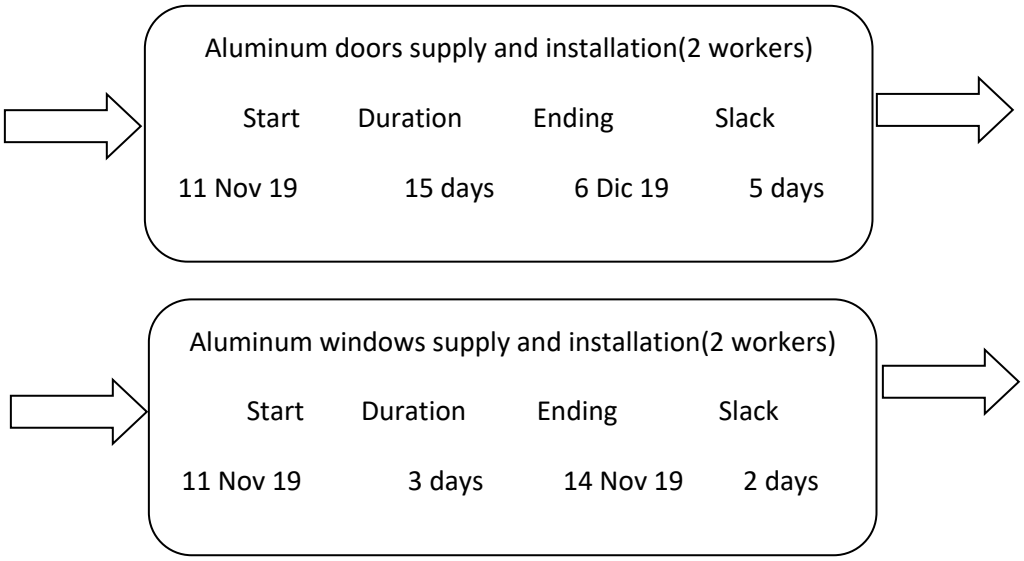

Figure 1. Initial slack analysis in schedules.

Note: Source: Author's creation (2020)

The graph shows how the 2 activities in the example start on the same date and in the first 3 days 2 workers are required for the provision and placement of aluminum doors and 2 workers for the provision and placement of aluminum windows. However, if we perform a value analysis of this activity, we can place the activities as follows:

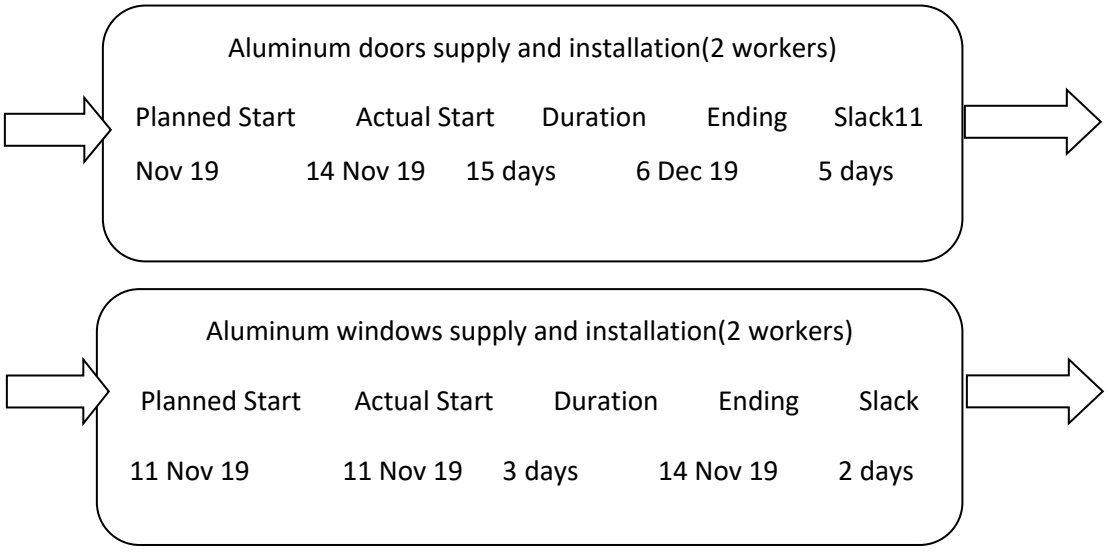

Figure 2. Value analysis in schedules.

Note: Source: Author's creation (2020)

With this value analysis performed only in 2 items of a project, the initial and final date of the activities have not been modified, what has been modified is the amount of personnel needed for its execution that at the beginning are 4 workers and now are 2 workers. A more in-depth analysis of the schedule for the entire project would lead to all the activities being on a critical path.

Results

In the PMBOK a whole set of written procedures is established to guarantee the execution of the project. While the Value Analysis processes within any methodology that guarantees the decrease of costs and time, innovating processes, materials in the construction that generate favorable economic results to the project.

In the PMBOK, it is indicated which tools are used for time management in the project activities including subcontractors, suppliers, and other participants that are necessary for its execution. In the Value Analysis of Construction, it is analyzed the activities of each one of the components of the project, verifying that part of these activities generate value to it and how, as a whole, it can diminish times and costs using the same tools of the PMBOK.

The Construction Value Analysis is independent of any administrative methodology used in the execution of the project. It is a tool that must be applied before starting its execution to optimize the processes in materials, time, and performance, innovating in such a way that it generates positive results to the project.

In PMBOK, the use of schedules, critical routes, Gantt bars is stated to take a suitable control of times and costs of the project. Now, with the use of systems like MS Project, Visio, etc., there is a suitable control of the projects in time and cost, without considering a great number of programs that exist for the control of the projects. Whereas the Value Analysis in Construction uses these tools to optimize the dates of execution of the activities, reusing the clearances, minimizing the use of equipment and labor.

In the PMBOK, control of all the processes that are needed for the execution of the project is made, including expenses and indirect costs of the project. However, it does not indicate a technical way to minimize these costs and expenses that are indispensable for its execution. In the Value in Construction Analysis, it is verified economically how much represents to implement these necessary activities but that they do not generate value in the project, and it tries to innovate the way it is possible to be made these activities using other ways that minimize resources. An example, we find the communication between the project and the administrative area, which minimizes the resources using an integral information system that optimizes the time and control of the costs and expenses of the project.

The Value in Construction Analysis allows to verify in the research if any material has high costs for its use. Besides, it helps to find alternative materials that meet the same technical results, but minimizing costs. For example, we have the use of prefabricated

mortars that minimize many costs of manufacture of the mortar in work, especially if the volume of use is high.

Discussion and conclusions

Finally, the tools presented between the PMBOK and the Value Analysis in Construction, allow to identify the bases of action of each one, its application in the projects and its complement between the two. The Analysis of Value in Construction is a tool that optimizes the costs generated in any phase of the project. On the other hand, the PMBOK determines the standards that the professionals and personnel of the project must carry out to continue efficiently and technically the project.

Both are part of the same project, but the Value Analysis is a tool that can improve the performance of the PMBOK, increasing its results, improving costs, and times applying the technique of Value Analysis.

The Value Analysis in construction projects determines which activities are performed in the project if they are direct costs, indirect costs, direct expenses, and indirect costs. It also determines if the quantification that will be disbursed is the most appropriate for the project and if there are new innovative or existing alternatives that generate better benefits in the project.

It has been demonstrated that the Value Analysis can reduce the amount of personnel and equipment using the Pert CPM network's allowances, managing to modify the starting dates in each item/activity to use the least amount of labor and equipment in the project, meeting the requirements, but improving the costs.

The PMBOK refers to the management that professionals must carry out to adequately manage the project. On the other hand, Value Analysis is the tool used in the project to improve its profitability.

References

Alemán, F. (2012). *Análisis y evolución de los costos de los principales insumos del Sector de la construcción en el Ecuador en el período 2004 – 2011*. Lisboa: Escuela Superior Politécnica del Litoral.

Ballard, G. (2008). *The Lean Project Delivery System: an update*. Lean Construction Institute Journal.

Ballard, G., Howell, G. (1998). Shielding Production: an essential step in production control. *Journal of Construction Engineering and Management, 124* (1). doi: 10.1061/(ASCE)0733-9364(1998)124:1(11)

Bar, D. (2012). *El 60% de la innovación de las empresas constructoras es no planificada.* Retrieved from ttps://www.interempresas.net/ObrasPublicas/Articulos/101082-El-60-por-ciento-de-la-innovacion-de-las-empresas-constructoras-es-no-planificada.html.

Calzeta, M. (2012). *Ingeniería de Valor, beneficios y oportunidades de incremento de valor en obras de Ingeniería Civil.* (Tesis doctoral) Civil Universidad Autónoma de México.

Espejo, A., Véliz J. (2013). *Aplicación De La Extensión Para La Construcción De La Guía Del PMBOK - Tercera Edición, En La Gerencia De Proyecto De Una Presa De Relaves En La Unidad Operativa Arcata-Arequipa.* (Tesis doctoral). Pontificia Universidad católica del Perú.

Florio, M., Finzi, U., Genco, M., Levarlet, F., Maffii, S., Tracogna, A. y Vignetti, S. (2003). *Guía del análisis Costes-Beneficios de los proyectos de Inversión.* Unidad responsable de la Evaluación DG Política Regional Comisión Europea.

Haguiara, N. (1998). *Engenharia e análise de valor na manufactura e na constução civil.* (2 ed.). São Paulo: Ed. Blucher

Hernández, R., Fernández, C. y Baptitsta, P. (2014). *Metodología de la Investigación*. Sexta Edición. Editorial McGraw Hill, Ciudad de México, México.

Henderson, K. (2007). *Earned Shedule: ¿A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of the Real Project Data,* PMI Sídney Australia Chapter.

Horngren, C., Datar, S., Rajan, M. (2012). *Contabilidad de Costos, Un enfoque Gerencial*. México: Pearson Educación de México S.A. de C.V.

Kazaz, A., Ulubeyli, S., Er, B., Acikara, T. (2016). *Construction Materials-based Methodology for time-cost-quality Trade-off problems.* Creative Construction Conference 2016, CCC 2016, 25-28 June 2016.

Koskela, L. (1992). *Application of the New Production Philosophy to Construction*. USA: Department of Civil Engineering, Stanford University, Stanford.

Pons, F. (2014). *Introducción a Lean Construction,* Fundación Laboral de Construcción, Madrid – España.

Project Managenement Institute Inc. (2016). *Construction Extension to the PMBOK Guide*. Pensylvania, USA: Newtown Square.

Suarez, M. (2008). *Encontrando al Kaizen: Un análisis teórico de la Mejora Continua*. México: Tecnológico de Monterrey.

Subramani, T., Jabasingh, S., Jayalakshmi, J. (2014). *Analysis of Cost Controlling In Construction Industries by Earned Value Method Using Primavera*. Department of Civil Engineering, VMKV Engg. College, Vinayaka Missions University, Salem, India.

Valderrama, F. (2010). Dos modelos de aplicación del método del valor ganado (EVM) para el sector de la construcción. In *XIV International Congress on Project Engineering.*

Villegas, N. (2009). *Análisis de valor en la toma de decisiones aplicado a carreteras. Tesis doctoral*. Barcelona: Universitat Politècnica de Catalunya.

Vivan, A., Huertas, F., Paliari, J. (2016). *Model for kaizen Project development for the construction industry.* Brasil: Universidad Federal de San Carlos.

Wang, Y., Bai, S., Guo, Y. (2014). *Applied Research of Earned Value Theory in the Engineering Project Management.* School of Management Northwestern Polytechnical University.

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IMPORTANCE OF INFORMATION SECURITY IN CORPORATE INFORMATION TECHNOLOGY COMPANIES

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Abstract: The importance of information security in corporate information technology companies has the primary objective of proposing security measures to protect information in corporate information technology companies. In this sense, the research is a qualitative, exploratory and descriptive, as it is based on the search for bibliographic material that makes it possible to suggest security measures for the protection of information. Secondary data were collected systematically, looking for the keyword - security measures and their synonyms. The search was carried out in computerized databases, such as Google Académico® and the Portal de Periódicos Capes. A set of suggestions for security measures that enable corporate companies in the field of Information Technology to take advantage of has been identified. It is highlighted as a conclusion that the proposed preventive, detective and corrective measures must be involved in a security and contingency plan disseminated throughout the organization.

Keywords: Information security, Security measures, Corporate companies.

IMPORTANCIA DE LA SEGURIDAD DE LA INFORMACIÓN EN LAS EMPRESAS DE TECNOLOGÍA DE INFORMACIÓN CORPORATIVA

Resumen: La importancia de la seguridad de la información en las empresas corporativas de tecnología de la información tiene el objetivo principal de proponer medidas de seguridad para proteger la información en las empresas corporativas de tecnología de la información. En este sentido, la investigación es cualitativa, exploratoria y descriptiva, ya que se basa en la búsqueda de material bibliográfico que permita sugerir medidas de seguridad para la protección de la información. Los datos secundarios se recopilaron sistemáticamente, buscando la palabra clave: medidas de seguridad y sus sinónimos. La búsqueda se realizó

en bases de datos computarizadas, como Google Académico® y el Portal de Periódicos Capes. Se ha identificado un conjunto de sugerencias para medidas de seguridad que permiten a las empresas corporativas en el campo de la tecnología de la información aprovechar.
Se destaca como conclusión que las medidas preventivas, de detección y correctivas propuestas deben estar involucradas en un plan de seguridad y contingencia difundido en toda la organización.

Palabras clave: Seguridad de la información, Medidas de seguridad, Empresas corporativas.

IMPORTÂNCIA DA SEGURANÇA DA INFORMAÇÃO NAS EMPRESAS CORPORATIVAS DO RAMO DA TECNOLOGIA DE INFORMAÇÃO

Resumo: A importância da segurança da informação nas empresas corporativas no ramo da tecnologia da informação tem como o objetivo primário em propor medidas de segurança para proteger a informação nas empresas corporativas do ramo da tecnologia de informação. Neste sentido, a pesquisa é qualitativa, de cunho exploratório e descritivo, pois tem como base a busca por material bibliográfico que possibilite sugerir medidas de segurança para a proteção das informações. Os dados secundários foram coletados de forma sistemática, buscando-se pela palavra chave – medidas de segurança e seus sinónimos. Realizou-se a busca em bases de dados computadorizadas, como o Google Académico® e o Portal de Periódicos Capes. Identificou-se um conjunto de sugestões de medidas de segurança que possibilitem as empresas corporativas do ramo da Tecnologia da Informação possam usufruir. Destaca-se como conclusão que as medidas preventivas, detetivas e corretivas propostas devem estar envolvidas em um plano de segurança e contingência disseminadas em toda a organização.

Palavras-chave: Segurança da informação, Medidas de Segurança, Empresas corporativas.

Introduction

Information security has been a concern around the world, information has become very important, handling it requires great care, and it is necessary to create conditions to protect it. Therefore, it is impossible to say that we are totally safe, even when it comes to the security of first world countries. This is because the economic losses, the psychological, deontological, and ideological problems are very great, in the present century we face various difficulties to control cybercrime (*brute force*) and espionage (*sniffing*).

Sniffing is understood, according to the definition of the website CERT.br (2012 p.19), *"Traffic interception, or sniffing, is a technique that consists of inspecting data trafficked in computer networks, by using specific programs called trackers."*

However, coups, electoral fraud, leaking political information, state secrets and bank diversions (which are called the phishing technique) have been a cause for concern. Theft with credit cards such as credit card cloning, email spoofing, altering grades in the university database (Pharming).

Nevertheless, it is worth mentioning that information security has become the first concern reported in this article. In 2018, the main concern of the countries was to create a legislation to prevent crime and to be able to bring criminals to justice, because it is very difficult to detect when we are being the subject of a computer crime . The basic security mechanisms must be studied in depth, such as the identification, authentication, authorization, integrity, confidentiality and availability of the information.

Similarly, it is understood that the advent of social media also allowed for an increase in the number of attacks by computer viruses, spies for copying of credentials, user passwords, various codes that will be sent to a remote computer where hackers search

this information to commit crimes. Another technique widely used by *Crackers* is social engineering, the goal of which is to trick people into accessing information that allows them to enter computers or computing devices.

Based on these descriptions, the overall objective of this article is to suggest security measures to protect information in corporate information technology companies.

Method

This research is understood as qualitative, exploratory, and descriptive, since it is based on the search for bibliographic material that suggests security measures for the protection of information. Secondary data was collected systematically, searching for the keyword - security measures and their synonyms. The search was performed in computerized databases, such as Google Scholar® and the Capes Newspaper portal (Portal de Periódicos da Capes). Google Scholar® for Creswell (2010) is a free database that provides a wide variety of bibliographic searches from various sources, such as theses, abstracts, and articles, with the advantage of being able to obtain them in their entirety. Regarding the Capes Newspaper portal, it was chosen as a search source to offer access to the full texts of selected articles in more than 15,000 international, national and foreign journals, and 126 databases with document summaries in all areas of knowledge (Portal de Periódicos da Capes). As for the analysis, the use of descriptive data analysis is considered, since it allows organizing, summarizing, and describing the important aspects of a set of observed characteristics or comparing those characteristics between two or more sets.

Description of the main economic losses caused by the failure of information security.

Based on the literary search, some economic losses were identified when there is no precaution and control, or the use and application of measures based on information security.

Coopamootoo (2018) suggests that companies that protect employee privacy in online interactions:

> In offline interactions, we need to disclose information about ourselves to build trust with others. When we move online, there are differences: businesses must participate to facilitate online interaction and they need to keep information about us to do so. These companies have a duty to protect our privacy, but our information may be at risk of accidental data loss or malicious attacks.

However, the protection and privacy of information has been a concern and fear of users who have services in these companies. The vulnerability of the data that can be used for cyber-attacks, not only for the theft of computers in the case of bank data, but also through the use of social engineering and social networks.

Most users of modern information technology run many risks, as they allow failures due to the lack of caution and control of the cause. Many do not have specific information on security preparation, and the preparation must be based on knowledge, we must all know these information security techniques in order to protect, because experience shows that not only users, but also companies allow most of the time to expose their clients' data as mentioned by Futurelearn, (2018):

> TalkTalk's cyber-attack saw the personal data of 157,000 customers, including credit card details, which were released in October 2015. As a result, the company lost around £60 million and more than 100,000 customers, but the customers were also open to potential identity fraud: in some cases, scammers used the data that allowed them to appear as TalkTalk engineers, contacting customers and persuading them to install malware in their machines.

However, we are faced with a precarious situation, we note that, in addition to the company failing with the security system, customers also facilitate data theft, as they have no knowledge of information security and allow criminals to implement social engineering.

Nevertheless, cyber-attacks in recent years have brought many difficulties, the malware belongs to several groups of computer viruses of approximately 31 present families, for example, the trojan, worms or bugs, dropper and backdoor, are the basis of many economic losses, false identity, espionage, data theft, types of computer fraud and sending data to a remote computer, even if they are geographically distant or on different continents.

Investments in the financial area are at serious risk. Attackers are the basis of these situations, the evolution of cybercrime and cyberterrorism, clients are their targets because they have often neglected and allow their data to be stolen, and through digital thefts of the customers, the company is affected in the same way as its security system. Also, sometimes it allows the theft of information when it does not have an adequate security system to protect its data.

However, the company and customers must be protected to prevent unauthorized people from accessing their credentials and are equipped with all the information security tools, so corporate companies and others must be prepared to avoid economic losses caused by the violation of the security of customers, users, employees and former workers, who already know the entire security system. In this case, it is important to revitalize and restructure the entire security system to avoid such situations, security policies should not be known by third parties, this makes the company vulnerable.

Even speaking of credit card fraud in the United Kingdom, it is appropriate to present the graph of the economic losses of fraud over the years and to know its current status:

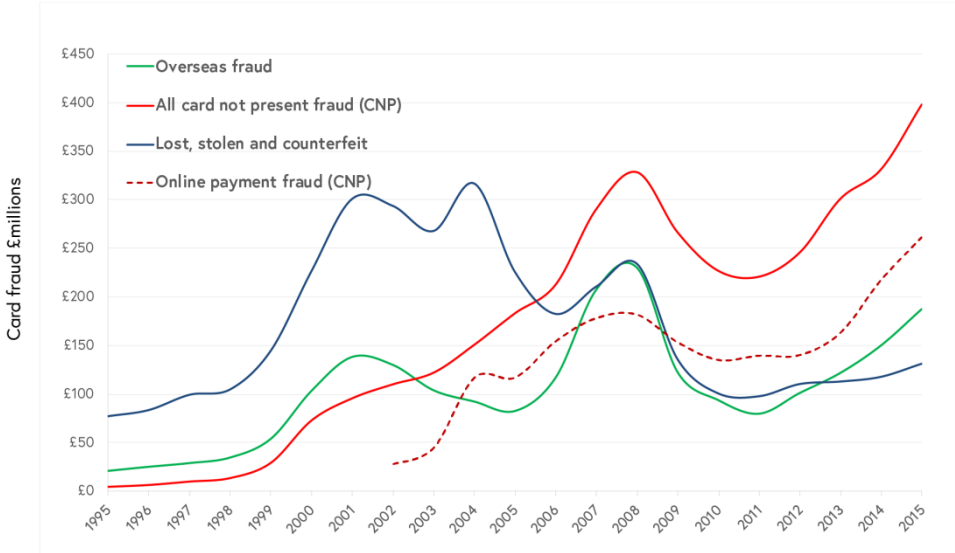

Figure 1. Chart of annual losses with cards issued in the United Kingdom
Note: Source: Futurelearn (2018).

By making a self-observation in figure 1, it is possible to analyze that from 1995 to 2015 there is a substantial increase in computer attacks on credit cards, which resulted from financial losses in the range of 0 to 450 million Euros, values that companies are subject to bankruptcy. Corporate companies with higher financial capital are likely to lose more when there is no prevention against Crackers and virtual pests.

In figure 1, it can be seen that the fraudulent payments made online have a scale of more than 250 million Euros, a large amount of money stolen by financial fraud, so it is necessary to avoid preventing cybercrime.

In the case of thefts, losses and counterfeits mentioned in figure 1, a scale of more than 300 million Euros is mentioned.

However, figure 1 also refers to credit cards made without bank fraud, in the order of 400 million Euros.

According to Financial Fraud Action in the United Kingdom (2017, p. 10): it presents the economic losses caused by thefts through online payments with credit cards: "Losses due to financial fraud in payment cards, remote banks and checks totaled £768.8 million in 2016, an increase of 2% compared to 2015." However, there are countless hardships and financial losses due to lack of information security, and we often notice that some companies expose our data and this has generally caused fraud, and many seek compensation from the company, others do not, and remain silent without knowing where to go, in this case, we must be very careful, how and where we place our credentials, the type of social networks to which we belong, the type of business or online purchase, all these factors must be treated with special attention.

> New technologies eradicate existing ways of committing fraud, but they also introduce other vulnerabilities that scammers adapt to exploit. The chip and PIN made it difficult to use a stolen card and therefore the theft of the card was rejected. However, criminals have identified that online payment has become a weakness since they cannot use Chip and PIN. Online fraud is now the most common form of payment fraud in the UK (Financial Fraud Action in the United Kingdom, 2017, p. 18).

Faced with this fraud, what stands out is that each banking professional must be prepared to know how to administer the management of documents and processes and, in turn, the information and financial assets, must behave like a professional that the bank has. Like its flag, we do not know in concrete terms what the basis for extortion was, but we believe that banks should promote a balanced salary for their technical staff, such as training in the fields of information security, ethics, and professional ethics.

According to the Terra (2018) site:

> The leak of 11.5 million documents, the so-called Panama Papers, from the Panamanian law and consulting firm Mossack Fonseca, the fourth largest offshore law firm in the world, would have revealed details of hundreds of thousands of clients using offshore tax havens allegedly for tax evasion, money laundering, drug trafficking and arms trafficking.

In addition to the analysis of the banks, a close-up is also made on the two corporate mobile phone companies, which we can designate as competitors, Samsung and

Apple. These companies have a very robust security system, they have many experts in information security, to protect prototypes, patents, and the telephone industry. However, these companies are leaders in the international telephony market, but if advanced information security methods are not used in these companies, a failure is fatal, it is not necessary to be very careful, in this case we must be careful to avoid disastrous situations, such as in 2012 in California, where Samsung, accused of violating patents only for the appearance of the devices and touch functions, which was required to pay millions of dollars, we imagine that it is a prototype, the scandal would be greater. In this case, the South Korean company was forced to compensate, according to Oficina Net, (2015):

> On August 24, 2012, a jury in San Jose, California, convicted Samsung of violating a series of patents from its largest competitor, the same jury sentenced the South Korean company to pay the equivalent of $930 million in damages to Apple. For its part, the federal court of appeals of Washington, USA, confirmed, in parts, the decision of the San José jury, trying to reverse part of the sentence, alleging that Samsung was unjustly convicted of violating patents related only to the appearance of the devices and the touch functions of the mobile device of the Apple company.

Some practices in information insecurity.

After the damages caused by the main economic losses caused by the failure of information security, it is appropriate to mention several practices that allow failures in information security. Most of the information users make it possible for these failures to occur, because many of them have an inadequate education for the protection of computer data, which makes it possible, that is, it translates into an open door for cybercriminals, Crackers and computer spies who take the opportunity to commit cybercrime.

According to Laureano (2005, p. 15 apud. Shirey, 2000) we have the definition of some important terms regarding information security:

> Threats
>
> - Intelligent threat: circumstance where an adversary has the technical and operational potential to detect and exploit the vulnerability of a system;
> - Threat: potential security breach. Exists when there is a circumstance, potential, action, or event that could violate security and cause damage;
> - Threat analysis: an analysis of the probability of events and the consequences of detrimental actions for a system;
> - Consequences of a threat: a security breach resulting from the action of a threat. Includes: disclosure, usurpation, disappointment, and interruption.

There are several threats, as we can see that scammers use social engineering, becoming real of a given bank or service, persuading the client to register much to steal their credentials, Internet, especially social networks allow improper access to information, mentioning that one of the fastest ways of spreading computer viruses are pornographic sites. It is one of the criminals' favorites because even some, teenagers and adults, are unaware that criminals use these sites for computer theft. Since contamination occurs when we open the image or video, in this case, the virus has the ability to present itself as an attachment to the document and replicate in the host in no time.

According Martinelli (2008, p. 46):

> Many viruses disguise themselves as supposed games, features, in attachments. Virus creators also use social engineering to reach their victims, claiming registration with government institutions, security, pornography, and free fun. Infected text messages sometimes replace the sender's line by posing as acquaintances, increasing the chances of contamination.

However, computer viruses are so fast and destructive in the transmission process that each one presents its specificity. However, the rule is the same and is based on the behavior of biological viruses that attack human cells, while computer viruses attack operating systems in their respective files. Every company that handles information must have an information security control room to prevent their data from being lost. In this recommendation, the expense of any investment in information security is made, it is important to hire specialists in the area of information security or create a department that supervises the management of files and documents. Companies complain of various computer thefts because some of them do not invest in data protection.

Corporate companies must lead by example in data protection, they must not waste information because they are subject to loss of reputation and other financial losses. As an example, we can mention the Coca-Cola company, which would not like to know the formula for its soft drink.

Nevertheless, large companies have never failed and have always differentiated themselves by protecting their assets. Try to imagine the security system that these companies have, which requires a lot of control and investment. However, it is understood that this culture must be transferred to other corporate companies.

According to Laureano (2005, p. 17):

> To implement security mechanisms, it is necessary to classify the possible forms of attacks on systems:

- Interception: access to information by unauthorized entities (violation of the privacy and confidentiality of the information) is considered interception.
- Interruption: can be defined as the interruption of the normal flow of messages to the destination.
- Modification: consists of the modification of messages by unauthorized entities, violation of the integrity of the message.
- Personification: personification is considered as the entity that accesses the information or transmits a message posing as an authentic entity, a violation of authenticity.

When addressing the information security mechanism, it is necessary to mention the type of physical security (*Hardware*) and logic (*Software*). They must be studied in depth because, for the most part, we are more cautious in one and not the other. It is recommended that there is no point in having a robust logical security (*software*) mechanism and an unprotected physical security system (*hardware*), which can happen is the theft of computing devices.

It is suggested that one be prepared for both forms of information security and invest a lot to have protection in our facilities and within a certain perimeter.

Trace the different ways of computer theft

According to Oliveira (2009, p. 14-15), organizational threats are divided into five:

- Physical threats;
- Logical threats;
- Occupational threat;
- Threat to confidentiality;
- Environmental threat.

Although there are various threats in companies, at this time we will emphasize physical and logical threats, as this is the objective of our investigation.

> However, malware is software designed to infect any program. Worms have the ability to replicate. Spyware programs are designed to spy on users and collect information to monitor the victim. Phishing is generally sent by email and captures extremely confidential information to carry out the fraud later (Quissanga, 2015, p. 6).

However, it is known that there are several types of computer crimes, which are performed by computers, executed through the Internet, in technological, digital form and other crimes of a legal nature. Computer theft is more widespread, so some do not have a law, regulation or criminal code; however, in the current context, countries see studying methods to arrest cybercriminals, a task that has not been easy, some articles or decrees used out of context that harm or benefit criminals are considered too far from reality. Despite this, the control of computer thefts must be made a deeper and more complete study, implementing detection measures, because there are various forms of cyber attacks.

Nevertheless, companies must be prepared to prevent attacks, this implies using all security devices, both logical and physical, and training their technical personnel or hiring companies specialized in the area of information security, in case they do not have all security tools when we are exposed on the Internet, we become more vulnerable, for this reason we need to implement the firewall to avoid unnecessary traffic that can be a transmission route for computer viruses, in this case all foreign packets, that is, not authorizing the firewall removes, denies all suspicious packets, allowing only authorized ones.

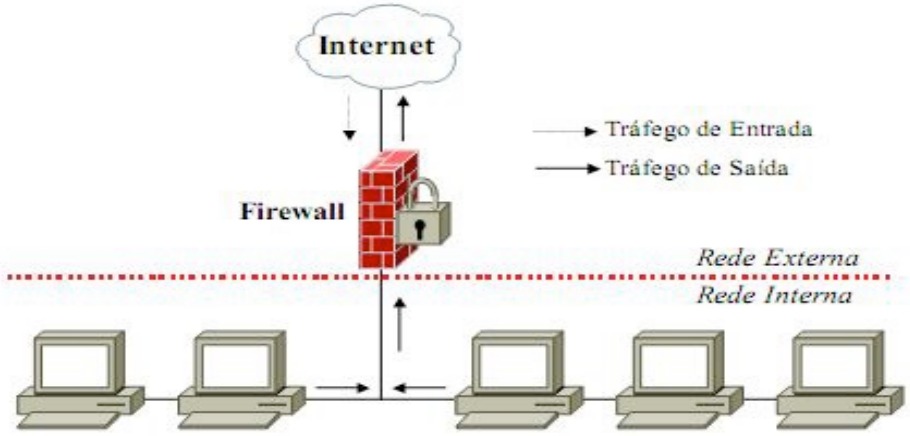

Figure 2. Defense is more complex than the attack.
Note: Source: Oliveira (2009, p.28).

However, in figure 2, it can be analyzed that defense is more complex than attack. Therefore, we must be prepared to avoid any violation of information security, because if we are attacked, we will hardly be able to defend ourselves from the attack. The term hacker is still widely debated, but we prefer to use Cracker because

it has a clear definition of cybercriminal. The Hacker, on the other hand, does not necessarily practice a virtual crime, but both have the same capabilities as the Hacker, but he presents himself defensively and is generally hired to protect a company's security system.

Computer theft forms are very quiet and unpredictable. Therefore, choosing a security method has been a great challenge, due to the problems we live in. While some study ways to protect themselves, others spend a lot of time to detect any information that allows virtual fraud; however, the forms of attack are diverse, each with its specificity, each case is a case, so it has been difficult to detect real security flaws.

Oliveira (2009, p. 40) basically mentions that the attackers carry out the following steps:

Step 1: The attacker, when it penetrates its network, breaks a certain machine.

Step 2: Installs a sniffer program.

Step 3: This program monitors the network to access network services, traps are made and recorded in a log file.

Step 4: Then the attacker recovers the log file.

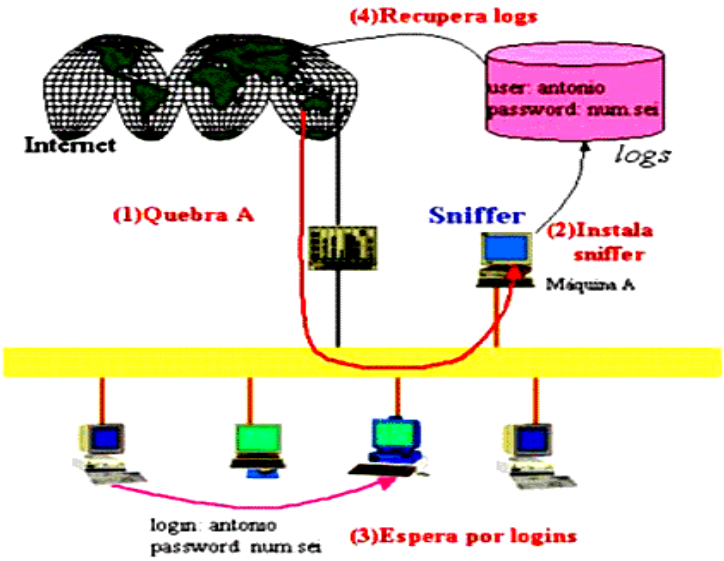

Figure 3. Information theft
Note: Source: Oliveira (2009, p. 40)

Today's corporate companies present computer programs or applications for bank transfers, balance inquiries, extract statements and various types of online payments, these tasks make some users vulnerable because they have no security education, these operations are generally performed by cell phone devices used by people who can access credentials, not to mention other forms of cybercrime. Bank fraud, in addition to social engineering, also sends strange messages, or emails, that generally contain malware or spyware. For example, we can analyze phishing.

Implementation of information security measures.

It is important to have basic training in security techniques, companies must train their employees to improve information security.

According to Oliveira (2009, p. 10) "It is useless for an organization to act virtually if the information fed into the system is vulnerable. Just as this is a differential factor for globalization, vulnerability can lead to the failure of a company".

The following are some unsafe practices:

1. Open suspicious email;
2. Online purchases with credit cards from unreliable companies;
3. Leave the Bluetooth on on your cell phone;
4. Install software on your phone from sites outside the Play Store, App store, itunes store, and Google store;
5. Allow your mobile device to be unprotected;
6. Allow unauthorized people to access your credentials;
7. Use of suspicious websites;
8. Use your computer without a strong password;
9. Use of misleading advertising;
10. Using storage devices on infected computers;
11. Use dubious source multimedia sharing;
12. Using an unprotected wireless network;
13. Using a computer without updated or unprotected antivirus;
14. Use a server without antimalware, antispyware and firewall.

Some companies also allow security breaches, either by hardware or software, but now we will address the failures related to the logical part:

Logical security flaws in companies:

1. Allow Crackers to monitor customer credentials;
2. Allow vulnerability in security systems;
3. Allow the cloning of customers' credit cards;
4. Allow the leakage of news and multimedia from customers;
5. Allow loss of confidential customer data and files;
6. Allow the diversion of bank details;
7. Allow deviations from formulas, patents, and prototypes;
8. Allow the change of academic data in the universities.

Physical or hardware security flaws that facilitate cybercrime:

1. Allow unauthorized access to the control or security room (social engineering);
2. Allow access to security cameras;
3. Allow access or theft of computing devices (HDs, external drives, USB sticks and CDs) that contain confidential information;
4. Due to lack of attention, allow the use of ATMs with cloned cards.

However, for information security measures, we recommend the SET protocol, according to Gonsalez (2011):

> The SET protocol (Secure Electronic Transaction) is a protocol created with the aim of providing security in time to carry out a transaction on the Internet. This protocol was created solely and exclusively to carry out secure electronic transactions that offer services such as:

- Authentication;
- Confidentiality;
- Integrity;
- Privacy;
- Immediate verification;
- No repudiation.

Many security measures are known to exist: preventive, detective, and corrective.

Preventive measures

These are precautionary measures against computer attacks. For example, servers are advised to install firewalls, use cryptographic techniques, set a strong password, create backups or redundant backups. For computing devices like computers, we recommend installing a complete, full-featured antivirus, especially antimalware, antispyware, and antispam, and undergo a constant update process. For physical control, you must install surveillance cameras, alarms, hire a physical protection company to control the space, and you need to hire a Hacker to monitor and test security systems. Without forgetting the training of technicians in the security system.

Detection measures

These measures are necessary when you want to monitor or audit your company's security or if there is an attacker tracker. These are measures that can carry out is to the presence of the Hacker hired to monitor all resources and report the security status of the company.

Corrective measures

Measures of this type are worrisome, but their impact is greater when the previous measures were not carried out in their entirety, although we have previously stated that the security problem is very delicate and requires large investments that companies are not always financially prepared to support this situation. They are those that happen in an emergency, without being planned, and damage the environment of information technologies, therefore, they must be resolved quickly for the health of the company. It is necessary to measure the risks as data loss are often irreparable, for this reason, the Hacker must assess the risks that have the company using this or that kind of security, knowing that so far we don't have completely safe security systems.

Security and contingency policy.

Physical threats;

> They are those to whom the used material resources in the information environment are exposed, putting the operational integrity of the organization at risk. Unfortunately, in many companies, they spend a lot on information security and end up forgetting to protect their assets (Oliveira, 2009, p. 15).

Physical security

Physical security is also very common, including fires, electric shocks, storms, electrical problems, misuse of equipment, inadequate access to the security room and the data processing center.

The physical security measures are:

1. Post guards in the control center;

2. Place doors with locks;
3. Installation of surveillance cameras;
4. Install alarms that transmit directly to the police control center;
5. Install fire extinguishers;
6. Install physical firewall;
7. Install eavesdropping systems;
8. Use No-Breaks.

According to Oliveira (2009, p. 15):

Logic threat

"These occur when there is a change in functional capacity due to fraud, accident, or resource error".

Logic security

Logical security is more extensive:

1. Cryptography: it is the art of writing and hiding codes so that the information is unrecognizable;
2. Firewall: it has the function of allowing or preventing packets. Being one of the foundations of security;
3. Circuit-level Gateway: it has the function of allowing or denying specific commands of specific applications through a proxy server, and they operate at layer 4 of the OSI model;
4. Bastion Hosts: are those that the hosts, before reaching the internal network, need to go to bastion hosts first, with or without permission;
5. Behavior-Based Intrusion Detection: used to deviate normal user behavior;
6. Radius protocol: it is a client/server security system;
7. NAT - Network Address Translation: used to store IP addresses;
8. Network-Based Intrusion Detection System (NIDS): also monitor network traffic from headers and packet content;
9. Single Sign-On (SSO): is a method that uses transparent and unique authentication for various corporate systems;
10. Honeypot: it is widely used to test security systems, allowing greater visibility of the real state of the company, it is also used to preserve the network from attacks;
11. Virtual Private Network (VPN): they are responsible for guaranteeing the authenticity, privacy, integrity of data, especially encryption technology;
12. Kerberos: has a secret key for each user;
13. Knowledge - Based Intrusion Detection: attacks are detected as an antivirus;
14. Intrusion detection systems (IDS): aims to monitor and accompany the internal and external action of the network;
15. Write the URL in the browser: it allows to use the accredited sites in a secure way;

16. DMZ - Demilitarized zones: it is an intermediate network made up of a firewall, servers and a switch, which remains between the internal and external networks.

Results

The research was conducted to propose security measures for corporate companies in the information technology industry. In this understanding, two forms of protection of information security have been proposed: logical (Software) and physical (Hardware).

The basic security mechanisms must be studied in depth, such as the identification, authentication, authorization, integrity, confidentiality and availability of information.

Nowadays, there should be a special look at social media as they also allow numerous computer virus attacks, spying for credential copies, user passwords, various codes, allowing to send them to a remote computer and thus, let the Crackers commit the crime.

It is noteworthy that, although it is something that has already been widely studied and disseminated in the literature, the constant study and research on the subject of information security helps prevention, thus reducing unnecessary economic expenses based on preventive measures of security, which are precautionary measures. For computer attacks, for example on servers, it is advisable to install firewall, antimalware, antispyware and use cryptographic techniques, set a strong password, create redundant backups or backups.

As for detection measures, these are needed when you want to monitor or audit security in companies or if there is an attacker tracker. These are measures that can be carried out with the presence of the hired Hacker to monitor all resources and report the security status of the company.

Regarding corrective measures, it is worrying, but its impact is greater when the previous measures are not carried out in their entirety. Finally, it is recommended that, in general, a contingency plan be adopted to avoid attacks on corporate companies so that all the proposed measures can be implemented.

Conclusion

Cyber attacks have brought many difficulties, malware belongs to several groups of computer viruses, such as trojan, worms or bugs, dropper and backdoor, they are the basis of many economic losses, false identity, espionage and data theft, types of computer fraud and sending data to a remote computer, even if they are geographically distant or on different continents.

The economic losses caused by failures in information security have turned into a scandal involving great figures in the world. However, coups, electoral fraud, leaking political information, state secrets and bank diversions have worried everyone. However,

policies to create legislation to punish cybercriminals are the best way out. These cases woke up the international community as corporate governments turned their intentions on information security, which was a national concern that has now become a global problem.

As for these attacks on companies, they are known to be more expressive by Crackers or Hackers , and a less representative number of former employees. To this end, it is recommended that preventive, detective and corrective security measures be used within a security and contingency plan.

The identified and proposed security measures are based on physics and logic. For the control of physical security, special attention is paid to the physical environment of the organization.

Regarding logical security, which is more comprehensive, especially for information security for corporate companies, the suggestion is the use of cryptography, the use of a firewall that allows or prevents the entry or exit of important data packets.

References:

CERT.br. (2012). Cartilha de Segurançapara Internet: Interceptação de tráfego (Sniffing). 4.0-Versão. São Paulo. Disponible en: http://cartilha.cert.br/.

Coopamootoo, K. (2018). Cyber Security: Privacidade online e offline. [vídeo]. Newcastle University. Retrieved from https://www.futurelearn.com/courses/cyber-security/0/steps/19596.

Creswell, J. W. (2010) Projeto de pesquisa métodos qualitativo, quantitativo e misto. In: Projeto de pesquisa métodos qualitativo, quantitativo e misto.

Financial Fraud Action UK. (2017). Fraud The Facts: This category covers fraud on cards that have been. Retrieved from https://www.financialfraudaction.org.uk/fraudfacts17/assets/fraud_the_facts.pdf.

Futurelearn. (2018a). Cyber Security: Riscos pessoais decorrentes de violação de privacidade nos negócios. [vídeo]. Newcastle University. Retrieved from https://www.futurelearn.com/courses/cyber-security/0/steps/19598.

Futurelearn (2018b) Cyber Security for Small and Medium Enterprises: What can we learn from this attack? Universidade Deakin. Retrieved from https://www.futurelearn.com/courses/cyber-security-business#what-is-upgrade.

Gonsalez. Y. J. (2011) Que es Protocolo SET. Universidad de le Salle. Retrieved from https://www.researchgate.net/publication/261551164_QUE_ES_PROTOCOLO_SET

Martinelli, H. (2008). *Vírus de Celular: Estudo e classificação para um protótipo de defesa: O início das ameaças: Quanto às formas de propagação mais comuns temos*. Uniritter. Brasil - RS, Porto Alegre.

Laureano, M. A. P. (2005) Gestão de segurança da informação. Retrieved from http://www.mlaureano.org/aulas_material/gst/apostila_versao_20.pdf.

Oficina da Net. (2015) Samsung é condenada a pagar indenização milionária a Apple. Retrieved from https://www.oficinadanet.com.br/post/14544-samsung-e-condenada-a-pagar-indenizacao-milionaria-a-apple.

Oliveira, G. (2009). *Segurança de redes:As ameaças organizacionais.* Escola Superior Aberta do Brasil - Vitoria - Espírito Santo.

Quissanga, F. C. (2015).*Caracterização de vírus informáticos em telefonia móvel celular:Propagação e infecção.*(Trabalho de conclusão do curso) Escola Superior Aberta do Brasil -ESAB - Vitoria - Espírito Santo.

Portal de periódicos capes. Missão e Objetivos. Retrieved from https://www.periodicos.capes.gov.br/index.php?option=com_pcontent&view=pcontent&alias=missao-objetivo&Itemid=144.

Terra (2016). Panama Papers. Retrieved from https://www.terra.com.br/noticias/mundo/panama-papers-geram-denuncias-e-investigacoes-em-todo omundo,814039f797239995dea030884e41f8faakajlviv.html.

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MODELS OF MANAGEMENT OF ICT SERVICES IN PRIVATE SCHOOLS IN THE CITY OF SÃO PAULO

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Abstract. The use of standards or models for managing ICT services is not new in Brazil, however there is a lack of information about the applicability of these models. The main objective of the study was to conduct a survey of ICT service management models practiced in private schools in the city of São Paulo, and after data collection, cross-check information with internal customer satisfaction levels (in particular, coordinators) of each institution so that it is possible to understand the relationship between the high quality levels of schools and the ICT service management models applied in these institutions. For data collection, a questionnaire was applied to each professional profile, the ICT manager and the pedagogical coordinator, with the intention of deepening the knowledge about the sector. The selected sample consisted of 67 ICT managers and 69 pedagogical coordinators. Through the verification of the data it was possible to understand part of the relationship between the supply of equipment, wireless networks and technology support services, with the perception of quality of the pedagogical professional in the same elementary school. As a result of both researches, it was possible to understand the direct relationship between a well-equipped school and professionals trained in the daily care of the teacher.

Keywords: Technology application in schools, ICT service quality, ICT service management models.

MODELOS DE GERENCIAMENTO DE SERVIÇOS DE TIC EM ESCOLAS PARTICULARES NA CIDADE DE SÃO PAULO

Resumo. O uso de padrões ou modelos para gerenciamento de serviços de TIC não é uma novidade no Brasil, no entanto é notória a falta de informações sobre a aplicabilidade desses modelos. O objetivo principal do estudo foi realizar um levantamento dos modelos de gerenciamento de serviços de TIC praticados nas escolas particulares da cidade de São Paulo e após a coleta dos dados efetuar um cruzamento das informações com os níveis de satisfação dos clientes internos (em específico, os coordenadores pedagógicos) de cada instituição para que seja possível entender a relação entre os altos níveis de qualidade das escolas e os modelos de gerenciamento de serviços de TIC aplicados nessas instituições. Para levantamento dos dados foi aplicado a cada perfil de profissional, o gerente de TIC e o coordenador pedagógico, um questionário com a intenção de aprofundar o conhecimento sobre o setor. A amostra selecionada foi de 67 gerentes de TIC e 69 coordenadores pedagógicos. Através da apuração dos dados foi possível entender parte da relação entre a oferta de equipamentos, redes sem fio e serviços de suporte de

tecnologia, com a percepção de qualidade do profissional de pedagogia em uma mesma instituição de ensino básico. Como resultado das duas pesquisas, foi possível entender a relação direta entre uma escola bem aparelhada e com profissionais treinados em atendimento no cotidiano do professor.

Palavras-chave: Aplicação de tecnologia em escolas, qualidade de serviços de TIC, modelos de gerenciamento de serviços de TIC

Introduction

A major challenge for managers of information and communication technology (ICT) departments installed in private schools is balancing investment in technology infrastructure with the offer of a quality support service to keep the entire operation of the educational institution. This perception of quality, or value creation, is extremely difficult to measure, mainly due to the intangibility of the fact. It is up to the information and communication technology (ICT) manager to understand the most diverse needs, be they individual or corporate. However, meeting these demands, which are not always explicit, requires good processing between departments and, above all, a good relationship with their managers.

Rodrigues, Maccari and Simões (2009) found that ICT management is not adherent, mainly, in relation to the support of the business models in which it is inserted. For this reason, following the evolution of technology has proven to be a guide in the perception of quality by people who use the many services and tools available in a private educational institution. Digital literacy for teachers is gradually increasing and with each new offering of technology equipment or systems, the old model is immediately recognized as old and obsolete. It is a fact that modern private educational institutions, especially in the city of São Paulo, understood that their information and communication technology departments have a strategic alignment factor, as well as a highly profitable competitive differential. Many of these schools already offer technology-related subjects in their pedagogical curricula, such as: programming, robotics, and electronic game design classes.

Private schools (infant, primary and secondary education) in the city of São Paulo have different levels of infrastructure in information and communication technology and each has developed its own method of service management. Faced with this disparity, education professionals (pedagogical coordinators and other teachers) find a very complex academic universe in which they must act. These differences in the provision of the technological environment, the management of technological services and the service (support) can directly affect the perception of value and quality of the educational services provided to the schools in question. Infrastructure is very important for the performance of teacher activities and an environment with scarce resources is counterproductive for instructional activities (Mamedio and Santos, 2016) and can generate professional dissatisfaction.

On the other hand, the ICT manager hired by educational institutions, whether private or public, works more and more in a multidisciplinary way to offer their infrastructure and the maintenance of this ecosystem has turned out to be very complicated, due to the availability and integrity and reliability requirements of

educational environments, technological or not, are increasingly higher. This has been positively reflected in the profile of the ICT professional, since the demands for professional training increase considerably, Cunha (2007, cited by Salimo, 2017) anticipated the concept on the dynamics of society and technological development, which it also passes through educational institutions on a mandatory basis.

According to Gil-Flores, Rodríguez-Santero and Torres-Gordillo (2017), the increase in the supply of equipment only increases the teacher's perception of value in relation to the ICT environment for pedagogical use, due to the characteristics related to affinity, in some cases, are more important than the infrastructure itself. However, due to the complexity of measuring an intangible concept such as perceived value, the rigor of the research instrument in relation to the scale must be taken into account. Baş, Kubiatko and Sünbül (2016) understand that improving the instrument is vital to generate opinions that are often empirical and demonstrate that teachers' pedagogical beliefs influence the evaluation of the use of associated ICT in the classroom. For Bai, Mo, Zhang, Boswell and Rozelle (2016), the application of a structured program for the use of ICT in the classroom can improve the teacher's opinion regarding the technological ecosystem offered by the educational institution, while for Vanderlinde, Aesaert and Van Braak (2014) the school curriculum that uses ICT must have objectives for its implementation and insertion. Comi, Argentin, Gui, Origo and Pagani (2017) sought the relationship between the different ICTs used in the classroom and the possible improvement in school performance. However, it is a fact that little is known about the practices of teaching subjects. The technology is really effective in the long term.

The scientific community studies at length the understanding that only the provision of quality ICT infrastructure is not sufficient to improve student learning, but the relationship between the use of support services and technological equipment by the teacher, such as: interactive projectors, computers and educational software, and the result of the application of these resources in academic life, for both teachers and students, is still little explored. Comi et al. (2017) understood that students or teachers will not only benefit from the indiscriminate increase in the ICT infrastructure in the educational institution. The determining factor in this topic is the figure of the teacher, because it is of little use for a school to offer state-of-the-art infrastructure if the teacher does not know, or shows no interest, in using the resources. Therefore, students may not benefit from the entire ecosystem offered, which certainly thwarts any investment initiative by the high school administration. Scherer, Siddiq and Teo (2015) emphasize that the decisive action for the integration of ICT in the classroom is the utility perceived by the teacher and, certainly, this perception of the use of technology has a relationship directly proportional to the ecosystem offered by the Institution and effective use depends on how the teacher is comfortable with the equipment and services in the school where he/she works.

According to Davis (1989, cited by Scherer, Siddiq and Teo (2015)) because the teacher's perception of the usefulness of ICT is linked to the same belief system that he has, this makes it difficult to measure satisfaction and see opportunities for improvement, as some topics can be preconceived and even discriminated, without the possibility of careful evaluation. From this perspective, the implementation of ICT service management models can help increase the perception of quality and added value by prescribing standards and procedures for certain activities. Meléndez, Dávila and Pessoa (2016) discuss excellence in service through the use of ICT service management models. Certainly, a high quality of service for its internal clients is a great differential as well as a competitive advantage among private schools in the city of São Paulo, and little by little

the majority of these institutions are approaching a type of standard in the provision of infrastructure and services. However, in the case of ICT, the quality has not yet reached the true competitive and strategic operational capacity, highly desired by the management of these companies. Scherer, Siddiq e Teo (2015))

Method

The main objective of the work was to develop the proposal of a conceptual model for the management of ICT services that can be used in private schools in the city of São Paulo. For this, it was necessary to understand what are the main problems facing pedagogical coordinators, related to the reception of services from the support area. It was still necessary to understand what are the existing resources in each educational institution analyzed, both as a team and in the technical knowledge of the ICT team responsible for supporting the operation. Above all, it became necessary to understand how the ICT equipment and services offered by the technology department interfere positively or negatively in the quality perception of the pedagogical coordinator. Most of the existing research attempts to find the relationship between technology and its influence on learning, that is, how the application of certain systems with a focus on education improves (or not) student performance in certain subjects.

In the case of this research, the intention of the analysis was centralized in the role of the pedagogical coordinator, since this professional has characteristics of knowledge diffusion in the institutions in which he/she works, therefore, his/her perception of the quality and usefulness of the ICT ecosystem present in schools can be perpetuated for teachers, positively or negatively, without being able to form an opinion based on their own experiences. Therefore, the work is an applied research with a quantitative approach, based on bibliographic procedures and data collection through the application of two questionnaires and the scope of the study is descriptive. The research concern, as proposed by Terence and Escrivão Filho (2006) was to measure and analyze the causal relationships between the variables in a multivariate way, in an environment in which the installed infrastructure and the ICT services provided by the departments of Technology of the schools are positively related to the level of satisfaction of the pedagogical coordinators.

The population's choice for this work was to seek answers about the ecosystem of ICT technology and services offered in private schools in the city of São Paulo and to counter the responses of ICT professionals, the opinion of the pedagogical coordinators regarding the ICT infrastructure and services received through the schools' ICT departments. Directly, the population involved in this research are the ICT administrators (or equivalent positions) of private schools in the city of São Paulo and the pedagogical coordinators (or equivalent positions) of the same institutions that participate in the research..

As the sample size is small, 67 ICT managers and 69 pedagogical coordinators, the author was able to interact with part of the professionals with the aim of witnessing the situation of the ICT infrastructure of the schools involved in the study. To determine the type of sample, three main requirements were taken into account: the school should be located in the city of São Paulo, be private (public schools were excluded from the

study) and have at least 1,000 students. The research strategy allowed focusing on the feeling of quality that the pedagogical coordinators have in relation to the ICT equipment, services and skills of the technology teams present in the institutions participating in the study.

The analyzed variables were proposed according to similarity and seeking greater objectivity as recommended by Hernández, Fernández and Baptista (2013). In the first block of independent variables, presented in the questionnaire for the ICT administrator, the installed technological infrastructure, the services provided and the technical skills of the employees of the ICT department, allow to know the entire ecosystem in which the coordinators are located; pedagogical of educational institutions are inserted. On the contrary, the dependent variables focus on the perception of quality that the pedagogy professional sees in relation to the independent variables, that is, how the infrastructure, services and technical skills of the ICT department influence their opinion on the quality of this ecosystem. In both blocks there are variables that generated data on sex, age, and information relevant to the academic life of the study participants, making it possible to cross-reference the age groups and educational levels of the ICT managers and pedagogical coordinators.

The evaluation instruments were two surveys. The first questionnaire -in which the responses of the institution's ICT manager were compiled- was divided into four pages or sections: on the first page (ICT infrastructure), information was collected on the equipment offered at the school, in the second page (ICT improvements), the questions were directed to the collection of data on the number of professionals and the percentage of calls answered through the institution's ICT department, the third page (ICT maturity level) identified the profile of the ICT professionals of the schools, their professional certifications, as well as the level of technical knowledge in the areas of operation. Finally, the fourth page (adoption of good practices) collected data on agreed service levels, satisfaction surveys and machinery park monitoring. In the second questionnaire, the pedagogical coordinators, or teachers, were able to answer about their satisfaction with the ICT infrastructure, support services and technical skills of care professionals. The data collected through the questionnaires was aimed at preserving the identity of the person who chose to answer the survey, so that no information about the name, document numbers and contact appear in the results. The author's intention in maintaining the degree of confidentiality was to allow the participant to feel completely comfortable answering the questions and in no way could there be any doubt or fear about possible retaliation before the administration of his company in favor of the content of the answers. With this premise, the participants could feel comfortable with the confidentiality initially signed with the author of the research.

Taking into account the results obtained in the application of the instruments, it was possible to detect the relationships between a well-structured school, in terms of ICT equipment, service processes and support, as well as well-prepared technology service teams and satisfaction of the pedagogical career professional. The measurement after data collection was aimed at linking the abstract concepts initially presented as the subject of this study with the empirical factors and indicators that the author of this work intended to clarify.

Results

The results obtained are a consequence of the aforementioned methodology, with the aim of identifying and classifying the provision of services and infrastructure present in private schools in the city of São Paulo, mapping the technical capacity of the ICT teams assigned to the participating institutions in the study and verify the relationship between the management of ICT services and the satisfaction of pedagogical coordination with the services received from the ICT departments of their institutions. The sample was integrated with 69 pedagogical coordinators (and teachers) and 67 ICT managers selected by themselves, and all the participants completed the answers present in their questionnaires.

Reliability Statistics

Reliability calculations were divided according to the profile of the questionnaire. The coefficient used was Cronbach's Alpha. According to Hernández, Fernández and Baptista (2013), the closer the result of the coefficient is to 1, the more reliable is the result of the instrument. Following the parameter defined by the author, in which topics with an Alpha coefficient below 0.6 should be reviewed or eliminated, the decision to exclude 8 topics present in the ICT managers questionnaire was necessary, since the result of the coefficient it was set at 0.244, therefore well below the acceptable standard for review.

The author considered prudent to divide the calculation of the Alpha coefficient according to the segments of each questionnaire, that is, in the instrument dedicated to pedagogical coordinators, there were 3 segments for the qualitative evaluation (satisfaction with the ICT infrastructure, support services and technical skills of service professionals) and in the ICT managers instrument there were 4 segments (ICT infrastructure, ICT improvements, level of ICT maturity and adoption of good practices) and the level of maturity of the ICT segment was excluded due to non-compliance with the minimum coefficient to compose the investigation. Therefore, the result would not be distorted in the main questions to be analyzed. However, for the result the data was recomposed, to complete the final explanation.

Table 1

Reliability statistics of the variables of the pedagogical coordinator questionnaire.

Cronbach's Alpha	Cronbach's alpha based on standardized elements	Number of elements
.772	.670	4
.779	.799	7
.831	.835	3

Note: Created by the author (2019). Relationship between the number of topics and the evaluation segments: Satisfaction in relation to the ICT infrastructure (4 topics), support services (7 topics) and technical skills of service professionals (3 topics).

The three segments that made up the questionnaire for the pedagogical coordinator had an acceptable coefficient, the last of which (technical skills of service professionals) has the highest coefficient (0.831). The difference between the results did not affect the research in a negative way.

Table 2

Reliability statistics for variables of the ICT manager questionnaire

Cronbach's Alpha	Cronbach's alpha based on standardized elements	Number of elements
.771	.741	4
.723	.816	16
.823	.826	5

Note: Created by the author (2019). Relationship between the number of topics and the evaluation segments: ICT infrastructure (4 topics), improvements in ICT (16 items) and adoption of good practices (5 topics).

The coefficients of the questionnaire for ICT administrators in private schools in the city of São Paulo had very similar results to those of the instrument applied to pedagogical coordinators, therefore, they are acceptable and important to validate the instrument, since the questions are very complete and in some cases have no complement to each other.

Factor Analysis

A factor analysis was performed on each research instrument with the intention of identifying complex interrelationships between the variables without any initial assumption between the factors. Hernández, Fernández and Baptista (2013) emphasize the importance of manipulating two or more independent variables and the inclusion of two or more levels or modes of presence in each of the independent variables.

Acceptable values to indicate that factor analysis is appropriate in this investigation are between 0.6 and 1.0. It is true that the interpretation of the results of the Kaiser-Meyer-Olkin (KMO) test varies greatly from one author to another, but the author of this work specified the commonly accepted values.

Then, the Bartlett sphericity calculation was performed so that it was possible to analyze the probability that the correlation matrix has significant results in some of its variables. Bartlett's sphericity test is a test statistic that is applied to examine the hypothesis that variables are uncorrelated in the same population. The test verifies the hypothesis that the correlation matrix is equal to the identity matrix, in short, the linear association between the variables studied is attested.

Calculations performed with the PSPP software, an open source statistical calculation program, showed some variation, so the authors prioritized the battery of calculations at two different points in the research.

Table 3

KMO and Bartlett test in the pedagogical coordinator questionnaire

Kaiser-Meyer-Olkin sample adequacy measure	.735	
Bartlett's sphericity test	Approx. Chi squared	545.883
	gl	120
	Sig.	.000

Note: Created by the author (2019).

Observing the results, we have the KMO of 0.735, as shown in Table 3, thus showing an average relationship between the set of variables present in the research of the pedagogical coordinator. The sphericity test showed a Sig. 0.000, which shows that there is a correlation between some variables.

Although the value is close to the minimum acceptable (KMO of 0.6) for participation in the study, it was important to measure the constitution of all the questions present in both surveys. As the questions were divided into two survey profiles, one for the ICT professional and the other for the pedagogical coordinator, it was necessary to present each research segment individually to the calculations, in order not to distort the result.

The behavior of calculating according to the section of each questionnaire was reproduced at all the necessary times. The result of the work was not affected, since the author maintained the uniqueness of the study according to the initial research design.

Table 4

KMO and Bartlett test in the ICT administrator questionnaire.

Kaiser-Meyer-Olkin sample adequacy measure		.816
Bartlett's sphericity test	Approx. Chi squared	1525.406
	gl	528
	Sig.	.000

Note: Created by the Author (2019).

The results in the instrument relevant to the ICT administrator were slightly more expressive, with a KMO of 0.816. However, they still show an average relationship between the study variables. Bartlett's sphericity test-maintained Sig. 0.000, which indicates the relationship of the variables.

Assumptions versus survey questions

The specification of the hypotheses was addressed through the initial survey obtained in the literature review and previous research. It is important to reinforce that even taking into account the existing differences and proportions, especially in the case that much research is directed at higher education and with a focus on improving student learning through the use of applied technologies, a large part of studies could be helpful.

According to the common understanding regarding the hypotheses, the author of this work has delved into the research topic and developed the statement of the hypotheses that were discussed: the installed technological infrastructure and the ICT services provided by the technology departments of the schools are positively related to the level of satisfaction of the pedagogical coordinators.

According to Hernández, Fernández and Baptista (2013), the characteristics of the hypotheses followed the pattern of quantitative research, referring to a real situation, they must be understandable, the relationships with the variables must be clear and credible and the most important fact for him. The construction of the final object must be observable and measurable. With these parameters as reference points, the author focused on eliminating the hypotheses and, consequently, their model variables or concepts that could restrict the clear and precise understanding of the expected result.

The author of this work understood his hypotheses as multivariate causal relationships, since there are several possible relationships between the cause (infrastructure, services and skills) and the effect (quality perception of the pedagogical coordinator) of the ICT ecosystem. As for the research design, according to the characteristics, it is a quantitative, cross-sectional and descriptive non-experimental research.

Table 5

Research questions and their hypotheses.

Research question	Hypothesis
In the opinion of the coordinators of the pedagogical department, the support services (help desk and infrastructure), the networks and the maintenance of the information management systems provided by the department of information and communication technology (ICT) Does the school meet expectations?	• In the opinion of the pedagogical coordinator, the ICT infrastructure meets expectations (H1:% ≥ 80) • In the opinion of the pedagogical coordinator, the ICT services meet expectations (H2:% ≥ 80)
What are the opportunities for improvement in the services offered by the ICT department of the schools?	• For greater opportunities, more improvements (H3: OPORT1 ≠ 0 and H4: OPORT2 ≠ 0)
How can the adoption of the best practices present in the service management and corporate governance models contribute to increasing the level of maturity in the management of the services offered by the school's ICT department?	• For greater maturity, greater adoption of good practices (H5: MATUR ≠ 0 and H6: BOAPR ≥ 5)

Note: Creation by the author (2019). Variables naming convention: OPORT1 (opportunity for improvements in ICT products in the opinion of the pedagogical coordinator), OPORT2 (opportunity for improvements in ICT products and services in the opinion of the ICT administrator), MATUR (maturity of ICT) and BOAPR (models of good ICT practices).

Results of variables versus hypotheses

The calculation of the basic results of the variables was carried out through a frequency analysis resulting from the responses to the questionnaires applied to each profile of the participating professional.

The main questions were grouped together to raise and measure the perception of quality of the pedagogical coordinator in relation to the equipment, data networks (wireless or not), educational systems and support services maintained by the technology department of the information from the institution where you are employed. To guarantee the confidentiality of the information obtained, no data was compromised that would compromise the identity of the respondent.

Table 6

Measurement results of the expectations variables of the pedagogical coordinator and their hypotheses

Hypothesis	Variable measure	Percent
In the opinion of the pedagogical coordinator, the ICT infrastructure meets expectations (H1:% ≥ 80)	Overall, how satisfied or dissatisfied are you with the equipment provided by your institution's information and communication technology (ICT) department (pedagogical coordinator questionnaire)?	• Extremely satisfied = 40.58% • Moderately satisfied = 55.07% • Not very satisfied = 2.90% • Neither satisfied nor dissatisfied = 1.45%
In the opinion of the pedagogical coordinator, the ICT services meet expectations (H2:% ≥ 80)	In general, how satisfied or dissatisfied are you with the helpdesk provided by the ICT department of your institution (pedagogical coordinator questionnaire)?	• Extremely satisfied = 36.23% • Moderately satisfied = 44.93% • Not very satisfied = 13.04% • Neither satisfied nor dissatisfied = 1.45%

Note: Created by the author (2019).

The first hypothesis (H1) raised (in the opinion of the pedagogical coordinator, does the ICT infrastructure meet expectations?) Refers to the entire technological ecosystem offered by the educational institution. The quality perception of the pedagogical professional takes into account the equipment and the broadband offer (tablets, computers, laptops, projectors, Internet and wireless network). The minimum acceptance percentage defined by the authors was 80%. After adding the two percentages at the top of the evaluation, with the concepts extremely satisfied and moderately satisfied, the total value is 95.65%, a result much higher than the expected final value. This accumulated result reinforces the initial concept that private primary schools in the city of São Paulo invest heavily in technological infrastructure, which becomes a competitive differential in the market. For the newly graduated pedagogical professional, it is a great start to his career working in schools well equipped with modern classroom support systems.

The second hypothesis (H2) has mainly questions that raise the relationship between the support services offered by the information technology teams in schools and the quality perception of the pedagogical coordinator. In addition to the perceived quality in the use of equipment and connectivity networks by the pedagogical professional, the feeling of a good support service received complements the study. The expected percentage of the result of the variables that make up hypothesis H2 (in general, how satisfied or dissatisfied are you with the support service (assistance service) provided by the ICT department of your institution?) It was 80%. As in the result of the team quality hypothesis, the two main themes (extremely satisfied and moderately satisfied) were added to integrate the result. The percentage reached was 81.16%, which shows that in the private schools of basic education in the city of São Paulo, the support services of the ICT teams are within the expectations of the pedagogical coordinators.

Table 7

Results of the measurement of the variables of opportunity for improvement and their hypotheses for pedagogical coordinator and ICT manager

Hypothesis	Variable measure	Percent
For more opportunities, more improvements (H3: OPORT1 ≠ 0)	In your opinion, is there an opportunity to improve the products and services offered by the ICT department of your institution (questionnaire of the pedagogical coordinator)?	• Yes = 89.86% • No = 10.14%
For greater opportunities, more improvements (H4: OPORT2 ≠ 0)	What is the average monthly percentage of calls made at your institution? Consider all calls, such as infrastructure, systems, and network infrastructure (ICT administrator questionnaire).	• More than 81% = 44.8% • 71 to 80% = 35.8%

Note: Creation by the author (2019). Variable naming convention: OPORT1 (opportunity to improve ICT products from the point of view of the pedagogical coordinator), OPORT2 (opportunity to improve ICT products and services from the point of view of the ICT administrator).

The two hypotheses about opportunities in the technological environment each have the opposite opinion. In H3, the pedagogical coordinator understands the central question (in your opinion, is there an opportunity to improve the products and services provided by the ICT department of your institution?) It is measured through a closed answer (Yes or No). The authors' expectation when measuring this variable leads to the creation of an opportunity index with the two points of view (pedagogical coordinator and ICT manager) separate, but complementary to each other. The measured value of the

variable that constitutes H3 was 89.86%, that is, only 10.14% of the pedagogical coordinators cannot see any opportunity for improvement.

In the opinion of the ICT manager, the variables that make up hypothesis H4 (what is the average monthly percentage of calls made in your institution? Note that all calls, such as: infrastructure, systems and network infrastructure) have answers percentage measures, in which the manager had to choose the average number of successfully completed support calls in his department. Adding the two positive percentage values, the authors obtained a result of 80.6%, a result that means that there are still 19.4% opportunities for improvement in this regard.

Table 8

Results of the measurement of maturity variables and their hypotheses for ICT managers

Hypothesis	Variable me	Por ciento
For greater maturity, greater adoption of good practices (H5: MATUR ≠ 0)	In your opinion on a scale of 0 to 5 (5 is the highest and 0 the lowest), what is the level of control you have over your infrastructure?	• 4 = 47.8% • 5 = 22.4%

Note: Creation by the author (2019). Variable naming convention: MATUR (ICT maturity).

The maturity hypothesis (H5) met the most basic problems of the ICT administrator of the institutions. The main question was about the level of control that the manager has over his fleet of machines, people and services. A table of 5 points was presented (5 being the highest value and 0 the lowest value) and the result of the measured variable was added to the two points considered high to integrate the study. The sum was 70.2%, that is, 29.8% of the questioned ICT managers do not have an acceptable level of control over their ecosystem of technology and services.

The author tried to understand the main reasons why almost 30% of ICT administrators in private schools in the city of São Paulo do not achieve a minimally acceptable level of control, and in most of the responses the factor is mentioned economic (little money available). Another aspect of the responses was the lack of trained professionals, even in the case of managers, where low academic training and recent professional experience influenced the responses. Most managers interviewed also mentioned the fact that there is no standard in creating technology environments for schools, although there are good practice frameworks in the market, in none of the schools visited was there a clear and explicit statement of use of good practice standards.

Table 9

Results of the measurement of good practice variables and their hypotheses for ICT managers

Hypothesis	Variable measure	Percent
For greater maturity, greater adoption of good practices (H6: BOAPR ≥ 5)	At the end of each call, is there a specific satisfaction survey for that service?	• Yes = 32.8% • No = 62.7% • Not applicable = 3.0%

Note: Creation by the author (2019). Variable naming convention: BOAPR (use of ICT best practice models).

For the hypothesis about good practices, the correlated variables raised questions related to the measurement of the satisfaction of the calls answered through small opinion polls, generally embedded at the end of each event attended, the need to inform the management of the company about the performance of the IT department and employees and the existence or not of a specific and confidential communication channel for complaints related to the assistance provided by the IT teams of the schools participating in the study. The most important index was measured through the variable: at the end of each call, is there a specific satisfaction survey for that service performed? The result of the measurement brought to light a fact that is very illuminating about the main difficulties that ICT managers in private primary schools in the city of São Paulo, according to the result of the measurement, only 32.8% of managers ICT have a satisfaction survey on their closed support calls. A number considered high, 62.7% of managers have no idea of the result of the service provided by their support teams.

Discussions and conclusions

The study was carried out with the intention of verifying what equipment, systems, data networks (wireless or not) and support services exist in private primary schools in the city of São Paulo. The author was aware of the great difference between the research participants and, in part of the cases, an on-site visit was necessary to correctly orient the responses of the ICT administrators who agreed to answer the questions. Many of them expressed concern by exposing their companies to compromise their image in the educational market in which they operate. To minimize this discomfort, it was necessary to develop a confidentiality term that the author gave to each participant. Another solution found to not compromise the employees who chose to answer the questions was not to mention any name, document number, company marks or any other data that could put the company or the participating employee at risk.

The basic education segment is highly reactive and cautious about sharing information. However, the author realized that there are professionals who are determined to change this behavior, be it by creating meetings in a round table format or even informal associations with the purpose of exchanging experiences and good market practices. From these initiatives, it was possible to accelerate research and data collection for the composition of this work.

The author verified through data collection and verification of results that there is a large gap in companies in the private education segment in the sample of the population in which the study was conducted. Part of this difference lies in the lack of preparation of the institution's technology executive, because according to the data collected, part of the professionals who occupy the position of ICT manager in schools do not have formal training in technological governance, nor in financial administration and people management. On the other hand, the pedagogical coordinators, mainly the elderly, over 45 years of age, are concerned about the quality of the services received from the ICT departments of their institutions. Younger coordinators demonstrate a technology-focused approach such as: offering wireless networks, broadband quality, new computers and tablets, and modern educational systems. Certainly, for the technology professional inserted in this context, there is an enormous difficulty to adapt due to the context presented.

Another case that caught the attention was the fact that there was a lot of financial investment without prior planning, since most of the companies that participate in the study still have in their presidencies or directorates members belonging to the family of the founders, when not the founder is the principal director. There were few schools where senior management and finance professionals were identified. This characteristic certainly limits the strategic planning that the technology sector needs to gradually insert itself into the educational context.

The author understood that this study could be used as a reference for future works with the intention of mapping and monitoring the evolution of the private education market for basic education in the city of São Paulo. Due to the importance of these companies in the Brazilian context, since the capital of São Paulo (São Paulo) is a center that generates financial and educational opportunities. The best schools, colleges and courses are located in the city and this panorama has a tendency to improve the level of excellence that few Brazilian cities have.

References:

Bai, Y., Mo, D., Zhang, L., Boswell, M., & Rozelle, S. (2016). The impact of integrating ICT with teaching: Evidence from a randomized controlled trial in rural schools in China. *Computers and Education, 96*, 1–14. doi: 10.1016/j.compedu.2016.02.005.

Baş, G., Kubiatko, M., & Sünbül, A. M. (2016). Teachers' perceptions towards ICTs in teaching-learning process: Scale validity and reliability study. *Computers in Human Behavior*. doi: 10.1016/j.chb.2016.03.022.

Comi, S. L., Argentin, G., Gui, M., Origo, F., & Pagani, L. (2017). Is it the way they use it? Teachers, ICT and student achievement. *Economics of Education Review, 56*, 24–39. doi: 10.1016/j.econedurev.2016.11.007.

Gil-Flores, J., Rodríguez-Santero, J., & Torres-Gordillo, J.-J. (2017). Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure. *Computers in Human Behavior, 68*, 441–449. doi: 10.1016/J.CHB.2016.11.057.

Mamedio, M. de P., & Santos, A. V. N. dos. (2016). Desmotivação do profissional da educação. In *Congresso de Iniciação Científica, Estágio e Docência do Campus Formosa* (pp. 1–13).

Melendez, K., Dávila, A., & Pessoa, M. (2016). Information technology service management models applied to medium and small organizations: A systematic literature review. *Computer Standards and Interfaces, 47*, 120–127. doi: 10.1016/j.csi.2015.10.001.

Rodrigues, L. C., Maccari, E. A., & Simões, S. A. (2009). O desenho da gestão da tecnologia da informação nas 100 maiores empresas na visão dos executivos de TI. *JISTEM Journal of Information Systems and Technology Management, 6*(3), 483–506. doi: 10.4301/S1807 - 17752009000300006

Salimo, G. I. (2017). Os desafios da Era Digital no contexto do Ensino Superior em Moçambique. (Tesis doctoral). Universidade Fernando Pessoa, Porto.

Hernández, R., Fernández, C., & Baptista, P. (2013). *Metodologia de pesquisa* (5ª ed.). Porto Alegre: Penso.

Scherer, R., Siddiq, F., & Teo, T. (2015). Becoming more specific: Measuring and modeling teachers' perceived usefulness of ICT in the context of teaching and learning. *Computers and Education, 88*, 202–214. doi: 10.1016/j.compedu.2015.05.005.

Terence, A. C. F., & Escrivão Filho, E. (2006). *Abordagem quantitativa, qualitativa e a utilização da pesquisa-ação nos estudos organizacionais* (p. 1–9). Fortaleza: ABEPRO

Vanderlinde, R., Aesaert, K., & Van Braak, J. (2014). Institutionalised ICT use in primary education: A multilevel analysis. *Computers and Education, 72*, 1–10. doi: 10.1016/j.compedu.2013.10.007.

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