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EQUIPO EDITORIAL / EDITORIAL TEAM / EQUIPA EDITORIAL

SUMARIO • SUMMARY • RESUMO

Editorial

The MLS Project Design & Management is pleased to present this new issue highlighting, once again, the joint effort of our group of collaborators and emphasizing innovation as a primary tool in scientific-technological development and its importance through creative, collaborative, and comprehensive work, enabling the expansion of knowledge for both mankind, culture and society in the design of new projects. This new edition includes different topics presented in 6 articles that have been selected to address from the information of BIM projects, such as the importance of creating new methodological strategies that include computational models, music technology, and basic rules of harmonic composition, to the integration of proposals in the field of health and the experimental identification of organic components.

The first article presents a study on construction projects (BIM) in relation to their criteria before proceeding toward their completion, identifying that the primary purpose should not be the automation of results but to be able to identify how and when to extract information from BIM projects to achieve the Building Constructability Assessment.

The second article discusses, through computer models, the design of a methodological strategy that integrates tools, such as programming languages, design, and reuse of algorithms, as well as the execution of discrete stochastic processes that create melodies bounded by the basic rules of pop music composition. All this with the purpose of being able to reproduce them, in a controlled way via a device called MIDI (Musical Instrument Digital Interface).

The third article presents a proposal to redesign the public third-level health care system of the Cusco region in Peru to improve the resolution capacity of hospitals when treating chronic degenerative diseases. The study addresses the need to continue with more detailed research on noncommunicable and re-emerging diseases.

Business success is addressed in the fourth article, using financial indicators such as profitability, productivity, and sales growth, which are factors for the success of MSMEs in the health sector of the city of Huancayo in Peru which are presented through an econometric model. The results establish that the source of financing, strategic planning and the use of ICTs, management training, innovation, dedication to the business and advertising on social networks are significant factors for the model.

Continuing with article five, it presents a topic that addresses identifying the most relevant aspects in the development of projects for the indigenous Caucan in Colombia from the viewpoint of indigenous social organizations and their experts. The results establish that there is good conceptual knowledge on the part of the formulators, but it is not sufficient to have the level of expertise required to formulate and evaluate public investment projects in the indigenous Caucan.

Lastly, in the last article of this issue, an experimental study is presented in which the existence of organic components was identified from the analysis of construction fragments of the San Diego convent in Quito Ecuador. These fragments belonged to different colonial periods between 1597 and 1700, concluding the presence of nopal mucilage as a component of construction in colonial times.

Before finishing this editorial, it is important for us to thank the work developed by all the collaborating IT and technical teams, as well as the Iberoamerican University Foundation (FUNIBER) and the Universities that have provided all the material support so that this issue could be carried out, with the conviction that we are on the right path towards international recognition.

Dr. Luis A. Dzul López
Dr. Roberto M. Álvarez
Chief Editors

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CONSTRUCTIBILITY ASSESSMENT IN BIM PROJECTS IN BRAZIL

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Abstract. This research was derived from a portion of author's work developed in the theoretical basis of the author's master's degree thesis, carried out with the program Maestría en Diseño, Gestión y Dirección de Proyectos, at the Universidad Internacional Iberoamericana, UNINI Mexico (UNINI-MX). The author has experience in construction sector projects, their multi-disciplinary compatibility and teaching of specific software used in this segment, and was motivated by observation of the context in practice, and personal embarrassment. In other countries than Brazil it is a reality, rather than a novelty, that building design scores are approved in line with their constructability criteria made prior to the subsequent execution. It is also noteworthy that projects resulting from Building Information Modeling (BIM projects), among other exponentially augmenting techno-methodological advances in the speed of occurrence, quality and quantity of collaborations, increasingly require paradigms changes in civil construction, but make it easier to extract data that can be evaluated for buildability in an automated way. The purpose of BIM should not only be to automate graphical textual deliverables. This work sought to conceptualize, based on literature and experiences. How and when to perform information extraction from BIM projects, seeking the automation process of Building Constructability Assessments.

Keywords: Constructability, constructability assessment, buildability BIM, project management.

EVALUACIÓN DE CONSTRUCTIVIDAD EN PROYECTOS BIM EN BRASIL

Resumo. Esta pesquisa foi derivada de uma parte do embasamento teórico da tese de mestrado do autor, desenvolvido junto ao Programa de Maestría en Diseño, Gestión y Dirección de Proyectos, na Universidad Internacional Iberoamericana, UNINI México (UNINI-MX). O autor possui experiência em projetos do setor da construção, sua compatibilização e ensino de softwares específicos utilizados neste segmento, e foi motivado por observação do contexto na prática, e constrangimento pessoal. Nos demais países é realidade, e não novidade, a aprovação da pontuação dos projetos de edifícios, com relação aos seus critérios de construtibilidade, antes de se proceder a sua consecução. É notável também que projetos resultantes de modelagem de informações da construção (projetos BIM), dentre outros avanços tecnometodológicos entrantes de forma exponencialmente crescente na velocidade de ocorrência, qualidade e quantidade de

colaborações, cada vez mais, exigem mudanças de paradigmas na construção civil, mas facilitam a extração de dados que podem ser avaliados, com relação à sua edificabilidade, de forma automatizada. A finalidade do BIM não deveria ser somente a automatização de entregáveis gráfico-textuais. Este trabalho buscou conceituar, embasado em literatura e experiências, como e quando realizar a extração de informações de projetos BIM buscando a automatização da Avaliação de Construtibilidade de Edifícios.

Palavras-chave: Construtibilidade, avaliação de construtibilidade, edificabilidade BIM, gestão de Projetos.

EVALUACIÓN DE CONSTRUCTIVIDAD EN PROYECTOS BIM EN BRASIL

Resumen. Esta investigación se derivó de una parte de la base teórica de la tesis de maestría del autor, desarrollada en conjunto con el Programa de Maestría en Diseño, Gestión y Gestión de Proyectos, en la Universidad Internacional Iberoamericana, UNINI-México (UNINI-MX). El autor tiene experiencia en proyectos en el sector de la construcción, su compatibilidad y enseñanza del software específico utilizado en este segmento, y se motivó al observar el contexto en la práctica y la vergüenza personal. En otros países, es una realidad, y no una novedad, aprobar los puntajes de los proyectos de construcción, en relación con sus criterios de construcción, antes de proceder a su logro. También es digno de mención que los proyectos que resultan del modelado de la información de construcción (proyectos BIM), entre otros avances tecnometodológicos entrantes de manera exponencialmente creciente en la velocidad de ocurrencia, calidad y cantidad de colaboraciones, exigen cada vez más cambios en los paradigmas en la construcción civil, pero facilitan la extracción de datos que pueden evaluarse, en relación con su capacidad de construcción, de forma automatizada. El propósito de BIM no debe ser solo la automatización de los resultados gráficos-textuales. Este trabajo buscó conceptualizar, con base en la literatura y las experiencias, cómo y cuándo extraer información de proyectos BIM que buscan automatizar la Evaluación de Constructividad del Edificio.

Palabras clave: Constructividad, evaluación de constructividad, edificabilidad BIM, gestión de proyectos.

Introduction

Projects resulting from Building Information Modeling (BIM), among other incoming technological advances, require paradigm shifts in civil construction. The objective of this study is to investigate not only BIM deliverables from the "Delivery Based" perspective, based on deliverables, commonly proclaimed by several recent study fronts, but the study with the sole purpose of adopting the best construction solution that can be achieved through the prior evaluation of constructivity carried out before its execution. The problems derived from the low constructivity result in serious financial losses and delays in the schedules of almost all the works. Some are not even completed. This research tried to verify how to apply the concepts of constructivity to the efficiency of buildings, in BIM projects, in order to achieve a better management of the projects and an optimized achievement of the constructions of buildings.

Contextualization of the Brazilian Scenario

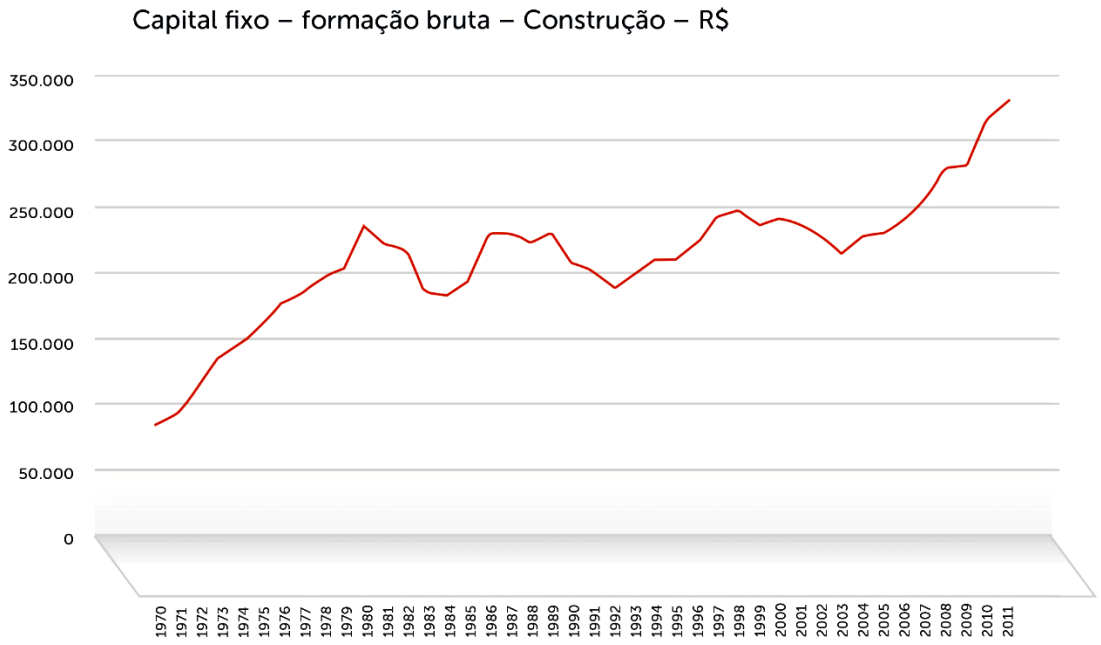

Figure 1. Fixed capital of gross formation of construction in Brazil, in reais (R$).
Note: Source**:** IBGE (2019) [website] (https://metadados.ibge.gov.br/consulta/estatisticos/operacoes-estatisticas/, recovered on July 1, 2019).

Figure 1 summarizes the historical context of the sample population. In half a century, the Brazilian economy has undergone numerous transformations:

The 70s: military governments and state investments.

The 80s: macroeconomic crisis, retraction of the supply of infrastructure and housing capital, acceleration of inflation and bankruptcy of the National Housing Bank (BNH).

From the 90s to the 2000s: the Plan Real, in 1994, established the necessary preconditions for the sustained expansion of the economy. Reactivation of investments with the Growth Acceleration Program (PAC). Mi Casa, Mi Vida Program(PMCMV), in 2009, with the expansion of real estate credit to low-income families. Fixed capital formation in construction. Growth of Brazil, with the expansion of sector employment. However, there happens to be a desire for higher qualification and productivity.

It should be noted that, throughout the world, the construction sector is considered to generate work of very low social status. According to Abdul-Aziz (2001), in Malaysia, “local youth prefer to be unemployed to work in the construction industry, due to archaic work practices, outdoor work and the prevalence of temporary and casual work.” In both rich and poor countries, people work in the civil construction industry when they have to with no choice, and leave the sector at the first opportunity. The most aggravating factor is the aging of the population and the disappearance of construction jobs during economic crises and the difficulty of recovering them when the scenario is reversed, since the civil construction workforce is reabsorbed more quickly by other sectors that tend to recover much faster. According to Neri (2014), in a study carried out by the FGV in association with the *Instituto Votorantim*, "construction is the second sector with the least participation in professional education, only surpassed by agriculture in Brazil."

Methodology

The analysis context has been delimited to the application of the constructivity criteria for the evaluation of BIM projects for buildings. Based on the bibliography directly or indirectly related to the topic, according to its original versions, or available copies, in Portuguese and English. The author citations of the English references received a free translation by the author. Although it is not the objective of this work, the future possibility of a more specific approach to the/other constructivity variables, BIM, /other incoming technologies and methodologies, in all its magnitude, is left open. This work focused on a projective and practical line of research, which allowed the application of the Constructability Assessment in BIM. Following the guidelines for the application of constructivity for project teams of the *Construction Industry Institute* (CII, 2012), this ensures that, on average, a total saving of 4.3% is generated in construction costs and a reduction in time of 7.5%.

Concept and theoretical framework

In 1962, in the United Kingdom, the *Survey of Problems before the Construction Industries*, popularized as the "Emmerson Report," was identified as the first publication to address the subject. It was a report commissioned to Lord Emmerson by the English government, motivated by low productivity, to investigate the state of the construction industry and propose improvements in the way in which professionals, builders and customers interact. The paper describes that "in no other industry is project responsibility so far from production responsibility," according to Emmerson (1962) apud Moore (1996a, p. 56). In the English *Design Buildings Wiki* (DBW, 2016) it is stated that the "Emmerson Report" motivated the identification of the problems derived from the separation between the project and its realization and encouraged the request of other reports by the government, such as the "Banwell Report," of 1964, which aimed to investigate the use of standardized contractual models. The "Banwell Report" concluded that the standardized models ended up creating "protection and concealment of information," segmenting communication and hindering productivity. "Low bid prices" were criticized for not taking other parameters into account, but the request was not accepted at the time, according to DBW (2016).

In 1979, the British *Construction Industry Research and Information Association* (CIRIA) made a series of recommendations to companies operating on standard English contracts and conducted several interviews with builders, which they complained about the "low buildability" caused by the bad relationship and lack of understanding with the designers. According to Moore (1996b), "low constructiveness" was used when talking about the low profitability that clients received for the amounts invested. The first definition of the term is attributed to CIRIA (1983), apud Wong (2007, p. 25), who stated that: "Constructivity is the way in which the design of a building facilitates its construction, subject to all general requirements of the finished building." He also ratified the relationship between the constructiveness and the fragmentation of the industry, pointed out in the "Emmerson" and "Banwel Reports." According to Moore (1996b, p. 4): "In order to obtain good constructiveness, it is necessary for designers and builders to be able to see the entire construction process through the eyes of the other." Thus was born the definition of constructivity as the ease of construction, and its dependence on the integration of the ideas of the different parties involved in a construction. Lam, Wong and Chan (2006) and WS Atkins (1994) approach the terminologies considering that "buildability," sometimes translated in Portugal as "edificability," translates into concern

for the design of the project, while "constructability," the American "constructability", translates into concern for all phases of the project. According to Wong (2007), even with their differences in approach and development, “buildability” and “constructability” are treated in the literature as two visions of the same concept. Research on the two terms is compared with each other, and there are cases where the difference in terminology does not even lead to a difference in ideas. In Australia, for example, “constructability” is used for both slopes, according to Francis (1999). In Brazil, “construtibilidade” is the only used term, leaving it up to each publication to define its meaning.

The 60s was the time of the breakthrough with old values and the creation of new musical, artistic and constructive movements, according to Reis, P. R. (2006). The architecture of this period, full of daring projects in Brazil and in the world, was used as an instrument of political, social and cultural manifestation. Not only the concepts of constructiveness, but also BIM, had their beginning in this troubled period. In 1974, Charles M. Eastman and his team at the Georgia Institute of Technology (USA) created the Building Description System (BDS). According to Eastman et al. (1974), the BDS showed that the description, with the use of a computer, of a building could reproduce and improve the strengths of construction and operation, as well as eliminate the weak points of the project. The idea introduced the migration of the drawing made on the drawing table to what was done with the use of CAD-type software, Computer Aided Design, in the 1980s. In the following decades, several commercial computational tools of the CAD type were developed. In 1992, Van Nederveen and Tolman first used the term “Building Information Modeling” (BIM), in an article that addressed the multiple viewpoints of building modeling, with the idea that building information modeling supported the structure of the model with the different perspectives of the various project participants.

According to Bryde; Skewers; and Volm (2013), BIM received more attention, evolving more from the 2000s, followed by research that popularized its advantages, its better quality and its low risk of propagation of errors. BIM is recognized and adopted by the industry in some countries; however, in others, government efforts are focused on promoting greater use and the benefits that technology brings, as is the case today in Brazil. BIM, according to the *National BIM Standard - United States* (NBIMS-US, 2016), is a “digital representation of the physical and functional characteristics of an installation, which serves as a shared knowledge resource of its information and constitutes a base reliable for decisions throughout the construction life cycle.” The construction information modeling not only constitutes a three-dimensional virtual model, but also makes it possible to control all the properties of the construction elements, allowing the automatic and instantaneous extraction of views (plans, sections, elevations, isometrics and perspectives) and information (tables and details). According to *Autodesk Knowledge Network* (AKN, 2019), parametric modeling, used in BIM, refers to the relationship between all the elements of the project, allowing the coordination and management of changes. Those relationships can be created automatically by both the software and the user. The "dimensions" of BIM deliveries, also known as multidimensional BIM, or nD BIM, considers, in addition to three-dimensional space (3D), the factors of time (4D), cost (5D), and building life cycle (6D) as dimensions of the model, according to McPartland (2017). The constructability assessment, which are automated with BIM, must take into account the graphical approach of Figure 2, in which the stages are expressed, the workflow of how organizations execute their processes in the construction of buildings.

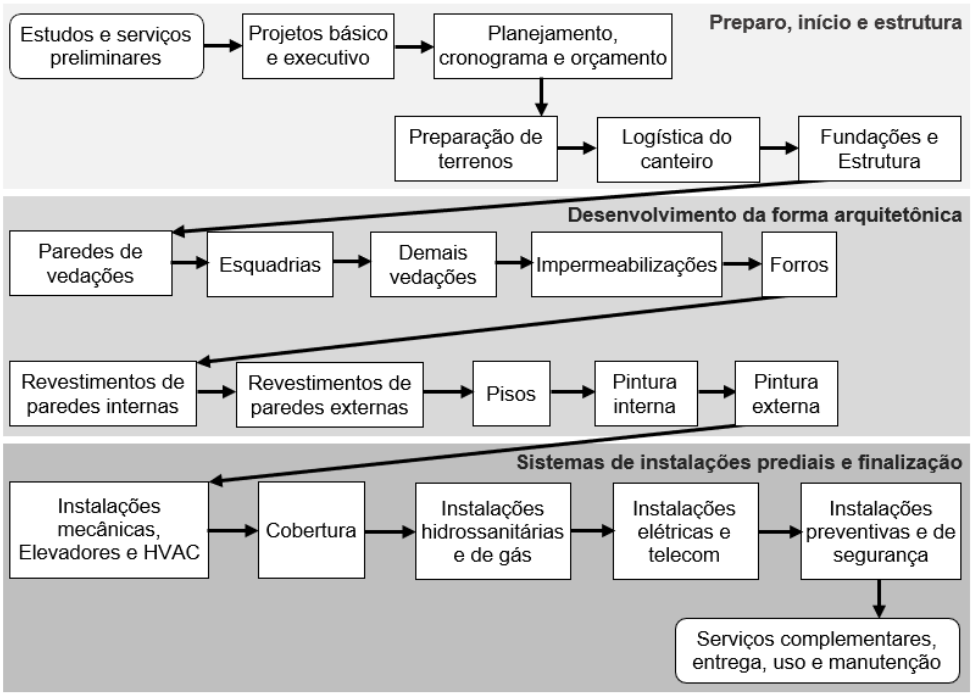

Figure 2. Process flow in the civil construction of buildings.
Note: Source: by the author (2019), based on the empirical experience and recommendations of CBIC, as well as the management software manuals of "Work Breakdown Structure," WBS.

Development of International Research

Based on the precepts of CII, CIRIA and international researchers, for the application of the constructivity guidelines, constructivity quantifications were created in order to provide greater support to the designers. According to Moore (1996b), since the 1980s the approach to Constructability Assessment has been quite varied, understanding that it is too broad to be quantified or that such methods could only be useful for some aspects without the possibility of a complete approach. According to Lawson (2006), the designers and architects rejected the first methods of rationalization and saw it as an invasion of their creative freedom, with the "standardization" and the consequent "simplification" of the project. That first impulse based on the Constructivity Guidelines was carried out with subjective processes, without a clear methodology, and therefore was not taken into consideration, although the literature continues to speak of the initial "Ratings" improperly taken as premature attempts to "Quantifications."

In terms of its benefits, there is a significant volume of publications around the world, from diverse perspectives. From those whose analysis is restricted only to the project, to those that cover the entire process and its completion and operation. From the most theoretical to the most practical approaches. Despite the diversity of approaches, the different authors have tendencies that converge towards common indicators. However, as there is no direct relationship between the different approaches, there is neither uniformity nor unanimity, which constitutes, to some extent, one of the major initial motivations for resisting the adoption of constructivity criteria. The qualitative trends of the main effects of constructivity that are most referred to are those of the American CII (2012), apud Wong (2007):

1) Reduction of the overall cost of the project;

2) Reduction of intensive work;
3) Increased execution speed;
4) Better quality of execution;
5) Increased safety in the workshop;
6) Reduction of rework;
7) Increase in productivity;
8) Decrease in the occurrence of unforeseen problems;
9) Better relationship between the team;
10) Increased customer satisfaction.

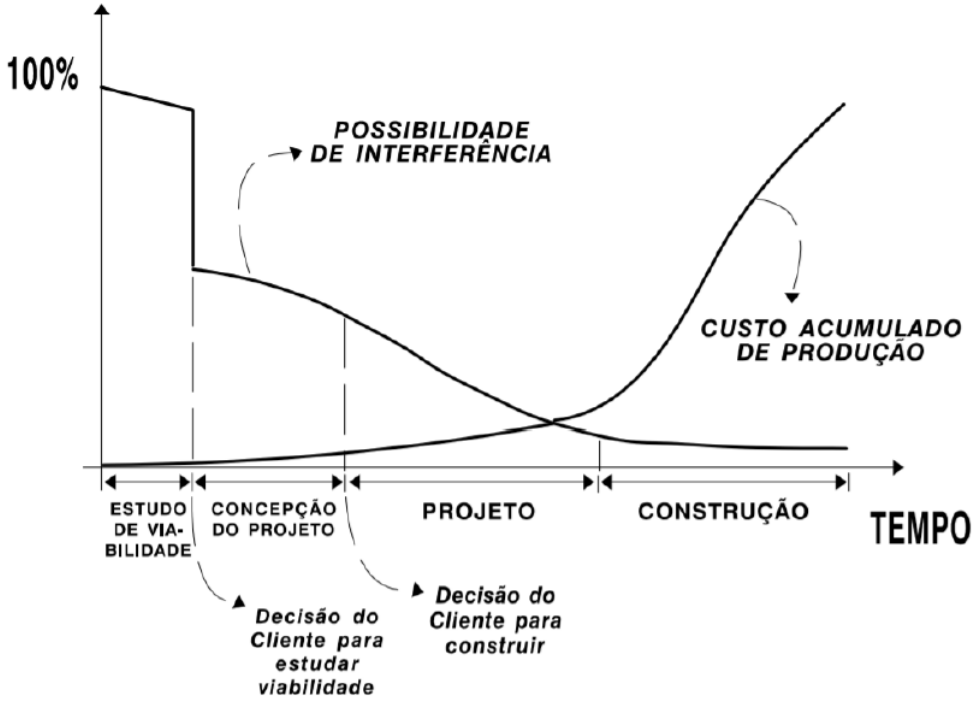

Figure 3. Relationship between the costs of the possibility of intervention and the accumulated production, through the phases of the construction project.
Note: Source: Hammarlund and Josephson (1992), apud Melhado (1994).

For the purposes of constructiveness, there is commonly the approach related to the optimal moment when the adoption of criteria begins to influence the project. There is consensus that better results will be obtained the sooner the adoption is made, preferably in the study stages, so that adaptations can be made, instead of making more difficult corrections, in terms of costs and deadlines. There are several graphs available that demonstrate the Pareto principle (20% of the efforts, generating 80% of the results), such as those of Hammarlund and Josephson (1992) apud Melhado (1994), which can be seen in figure 3.

Research on Constructivity in Brazil

There is little national research in comparison with international production, and most of it revolves around the American concept, more closely those of CII, from the

1980s. The limited development of national literature has translated the American concept of "Constructability" from CII, without any consideration, interpretation and adaptation to the Brazilian context. The American concept assumes the model of responsible “Project Management” (applied in the United States with the central figure of its “Project Manager), with little openness to responsibilities assigned to other leadership initiatives. Brazilian construction contracting and development models are more fragmented and decentralized, and diverge from American models. Regarding the human factor of resistance to change, it is observed that the imposition of complex translated definitions provokes rejection. The method should serve the context. Never the opposite. Besides being appropriate for the environment, the proposed method to assess constructiveness should aim to seek a pragmatic approach, adapting to the national context, to intervene in a simple, direct, effective and consistent way over time.

Most of the research carried out in Brazil deals with the Implementation of Constructivity, selects constructivity guidelines and proposes an implementation methodology. The concept of Constructability Assessment appears in some Brazilian works, which propose to quantify the qualification, with few references to relevant international works that have been produced since the 2000s, such as those that are under the influence of the adoption of sustainable solutions and disruptive methodological and technological advances. Heineck and Rodríguez (2003) provide examples of the definition and application of the Constructivity Guidelines in the project process. Saffaro, Santos, and Heineck (2004) repeat the format, also focusing on post-project decisions. Rodrigues (2005), in turn, focused on the study of the guidelines for repetitive works and proposed a Constructability Assessment system through a checklist in which the elements can be qualified as “yes,” “partially,” “no” or “not applicable.” Amancio (2010), who continued the work of Rodrigues, resumed the first attempts at quantification on the basis of the rating, focusing on architecture studies and proposed his model in which expert “judges” would subjectively assess the suitability of the work.

In Brazil, there is a constant interest towards constructiveness, but the research approaches were restricted only to some of its aspects. The early work focused more on implementation and later on analysis and quantification, many of them, however, resembling the early British attempts by CIRIA and O'Connor. Therefore, there is a pressing need for new works, a greater deepening and new attempts that favor the Constructivity Analysis to fill the “gap” with respect to the new sustainability criteria (for example, less waste, better physical-financial performance), better methodologies (for example, BIM, block chain) and technological advances (for example, dry construction, generative design), variables that make some research obsolete in the international context and more exhaustive.

Results and discussions

The concept of constructivity, depending on the place, time and context, and according to different perspectives and needs, proved to have different approaches. In the United Kingdom, when the concept was conceived, researchers with a clear epistemological focus focused on the clarifications and advantages of its implementation with immeasurable benefits on the international scene. In the United States and Australia, the most pragmatic approach was the Application of Constructiveness in the project process, which encompassed the knowledge transfer from field professionals to office professionals, with a large mobilization around the topic in the construction industry and

its practices, emphasizing the responsibility of its project manager. Construction Management contractual models continue to be used as a guarantee of interaction between field professionals, designers and clients, leading to greater constructiveness. However, it was evidenced that only the designers adopted the constructiveness implementation measures, without a large participation of the company itself and other actors. The companies that applied constructiveness did so in a more simplified way than that preached in universities. Even in a more conducive context, implementation took place partially due to strong resistance to change in terms of the need for different interactions and operations.

Brazil followed the American model of research on constructivity, a valid approach for an individual company where it is still under the leadership of its "Project Manager," but its application in the broader context of the sector is also very impractical of national construction as a whole. The Brazilian sector operates in a much more fragmented way, requiring a major break in patterns, as well as a huge, resilient and disciplined effort to implement change on a larger scale. Many of the constructivity lessons in Brazil come from the CII American and CII-Australia constructivity implementation models.

In Singapore, unlike other countries, the interest in researching and applying constructiveness came from the government. According to Lam, Wong, Tiong (2006), in the 90s, the construction industry was active and had a great demand for labor that, due to geopolitical characteristics, could not be supplied by the local population. The country depended on foreign workers. There was government interference to mitigate the problem. The adoption of constructiveness assessments was encouraged to reduce dependence on foreign human resources. The "Buildable Design Appraisal System," BDAS, was adopted, based on the system of Takenaka, a Japanese multinational construction company. According to the *Building and Construction Authority* (BCA, 2017), in 1993, BDAS began to be applied in public works in the country and in 1997 prizes were instituted for more constructive private projects. In 2001, all projects and renovations with an area greater than 2000 m² were required to obtain a minimum value of construction for legal approval. BDAS is based on three principles, the "3S" of constructivity: "Simplicity," "Standardization," and "Single Integrated Elements." The Singapore Constructability Assessment is numerical and deterministic, with little openness to subjective ratings of constructivity implementations present in other countries. Moreover, according to the tests carried out by the author, it can be realized concomitantly with the information from BIM projects, provided that adaptations are made to the context.

Since the 2000s, most of the most relevant research on constructiveness has taken place in Asia, with constructability assessment and scoring models, such as the Singapore BDAS, which was consolidated as the first case in which constructivity integrates the entire construction industry nationwide, with broad benefits. BDAS consolidated a simple method, which does not require changes in the contractual models and the internal functioning of the companies, and it was accepted immediately. Hong Kong's "Buildability Assessment Model," BAM, and its development, the "Scheme Design Buildability Assessment Model," SDBAM, were derived from BDAS and are also other successful examples of assessment models that were fully adapted to the context, which allows prior analysis in the design stage of the project, also becoming a model replicated throughout the world. According to the valid criticism of some authors such as Moore, the Constructability Assessment can become an extreme simplification of constructivity since many project variables that affect it cannot be quantified with simple formulas.

Implementation-biased approaches are the closest to the original epistemological ideas. However, both BDAS and BAM are internationally recognized for their proven efficacy in extremely simple and quantitative use compared to the extensive rating lists of CII methods, which justifies the possibility of a pragmatic use of Constructability Assessment methods more practical and effective for companies and the construction industry.

Historically, regardless of the context, in terms of Constructability Assessment it has been found that the adoption of very complex academic methods, such as those of CII, has almost never been fully followed. And the most current, simple and practical methods, such as those developed in Asia, offer a means that generates less resistance to change, which offers a more efficient and technological way to measure constructivity with greater ease and without requiring exchanges of procedural or contractual paradigms. Another point is the definition of constructiveness. Brazilian investigations unanimously adopted the American definition of "constructability," which would require, for its large-scale application, drastic changes in the industry with its conception based on CII models, with the figure of the "Project Manager," changes in the contract modality and continuous feedback between field and office professionals in "simultaneous engineering," as defined by Barbosa, P. and Andery, P. (2015). The differing view adopted by this work is that constructiveness, in a practical way, must be adapted to the reality of the industry, to the context in which it is inserted. Never the opposite. The simplest buildability analysis has a higher propensity for broad adoption. Adaptation to the Brazilian context is also possible.

In terms of context, Brazil, despite having adopted foreign workers, does not yet experience a severe labor shortage as in Singapore and Hong Kong, but has problems related to low constructiveness similar to those in the United Kingdom. For the concept to be accepted as advantageous, there must be a decrease in errors and an improvement in the relationship between the team, the studies must be carried out in partnership with the companies. The preparation of documents and instructional conferences are other possible and complementary actions. As a future proposal, a national online database on constructiveness could also be created, such as the one devised by CII-Australia. Just as the CUB and the budget composition tables, such as the SINAPI, are regularly updated; this bank could also receive feedback and improve cyclically.

The integration of constructiveness with information and communication technologies was little addressed in Brazil. In the international framework, with several recent publications, in English, in Hong Kong and South Korea, the automated processes of Constructability Assessment and BIM are related. The development of an enabling bridge that links them effectively would also lead to advances, in both approaches, to a new level.

Conclusions and Final Considerations

Despite the vast theoretical concept, a practical and automated demonstration of some means of extracting and using BIM information for the evaluation of the constructiveness of the entire building project has not yet been consolidated, covering all its construction disciplines. However, there are some main lines of focus to consider.

A means of weighing the data would be through the BIM 3D software itself, with direct information from the project modeling and its control by the user, such as the Revit used by Zhang et al. (2016), or the ArchiCAD. Zhang et al. (2016) address the

"Constructability" Assessment, defined according to the IIC, of the project as a whole, and develop a partially automated method in Revit, by manually inserting parameters in the construction components and using an additional "plugin" to verify the percentage in which the requirements are produced, which denote the indicators of constructivity of the project.

Another possibility of automation, also through software, is the use of BIM 4D planning tools for the calculation and validation of parameters, such as Solibri, used by Jiang (2016), Navisworks, Synchro or Tekla BIMsight. Jiang (2016) investigates the constructivity of reinforced concrete forms and the possibility of automating the Constructability Assessment, using the argument of Moore (1996b) that it is impossible to develop a simple method to evaluate the constructivity of the building as a whole. With little interdisciplinary deepening, Jiang (2016) used the Solibri to verify if the model respected the established parameters, but without the total automation of this process.

Another way is the use of a "written" programming language, such as C# or Python, and/or the use of "visual" programming, such as Dynamo or Grasshopper, as a more direct way of evaluating constructiveness. By using the programming language it is possible to have an internal approach, carried out for software from a certain company, such as ADN ("Autodesk Developer Network"), or through a routine that directly accesses the original file, such as Delegrego (2017) demonstrated, with the validation of the data directly from a *.ifc model.

"Industry Foundation Classes," IFC, is a file "sharing" extension intended for interdisciplinary BIM collaboration. According to McPartland (2017b) in collaboration with the "National Building Specification" (NBS, 2017), IFC is not a format controlled by a single company or group. It was designed and developed to facilitate interoperability in the AEC sector (Architecture, Engineering and Construction). In 1994, the "IFC Initiative," although open, came about when Autodesk formed a consortium with 12 American companies to help them develop a set of C++ programming to support embedded applications. The included companies: AT&T, HOK Architects, Honeywell, Carrier, Tishman, and Butler Manufacturing. Initially named "International Alliance for Interoperability," IAI, Industry Alliance for Interoperability, opened the template to all interested parties in 1995. Non-profit, industry-led, published the "Industry Foundation Class," IFC, as a neutral and standardized model. In 2005, IAI changed its name to buildingSMART, the current head of the format. Despite the full adoption of *.ifc in some countries, such as Denmark, and initiatives such as "OpenBIM" to promote it worldwide, there is no consensus on its use, even in countries where BIM is present. Although some computer programs use it as an alternative format, they never use it as the primary or native format, which, to some extent, fuels the controversy surrounding the adoption of the format, since its inception. As a simple explanatory parallelism, the author complements that the idea around IFC is similar to that of Adobe's PDF (Portable Document Format), in regards to text documents that can also come from different sources, which they maintain interrelation and fidelity in the exchange of information.

The necessary data extraction is possible directly in the file, with the software source extension, as demonstrated by Zhang et al. (2016) with the use of Revit, or in the external environment, as demonstrated by Delegrego (2017) with the IFC. By the author's point of view, one of the difficulties encountered is not the preference that the file format be in *.rvt or *.ifc, respectively, but the way in which the construction information is manipulated in the file itself. BIM 3D, with the delimitation in categories of parametric objects used. Although the delimitation in BIM categories facilitates and gives

consistency to the modeling of information, with the separation and predetermination of the individual properties of each element, in this way, it would only be possible to manage it externally if an evaluation model such as BDAS were adopted, in which several categories are grouped not always in a disciplinary way, to be analyzed together. It should be noted that not all Brazilian project offices have programmers who can overcome this barrier. The use of BIM to automate the evaluation of constructivity presupposes that the dimension of the information can be appropriate to the context of analysis. There are planning software such as Solibri, used by Jiang (2016) for the analysis of the constructiveness of reinforced concrete forms. Other BIM 4D software suitable for time dimension management include Navisworks, Synchro, and Tekla BIMsight. Due to the author's experience, in addition to the BIM 4D software that allow the generation of the calendar and its Gantt chart with assignment of tasks over time, they also offer the possibility of checking geometric interferences, and the extraction of "Quantity Take Off," QTO, among other accessory tools for planning. QTO allows the management of information without the need for intervention through programming. The planning software also allow the export, in a pivot table to Excel, software with a greater number of professional users. The QTO destination is usually the budget, the BIM 5D. Nevertheless, it can also be used, without restrictions, to assess constructiveness. The author's proposal, regarding the insertion of the Constructability Assessment in an interdisciplinary system for the delivery of BIM projects, and when it will be carried out, is shown in figure 4.

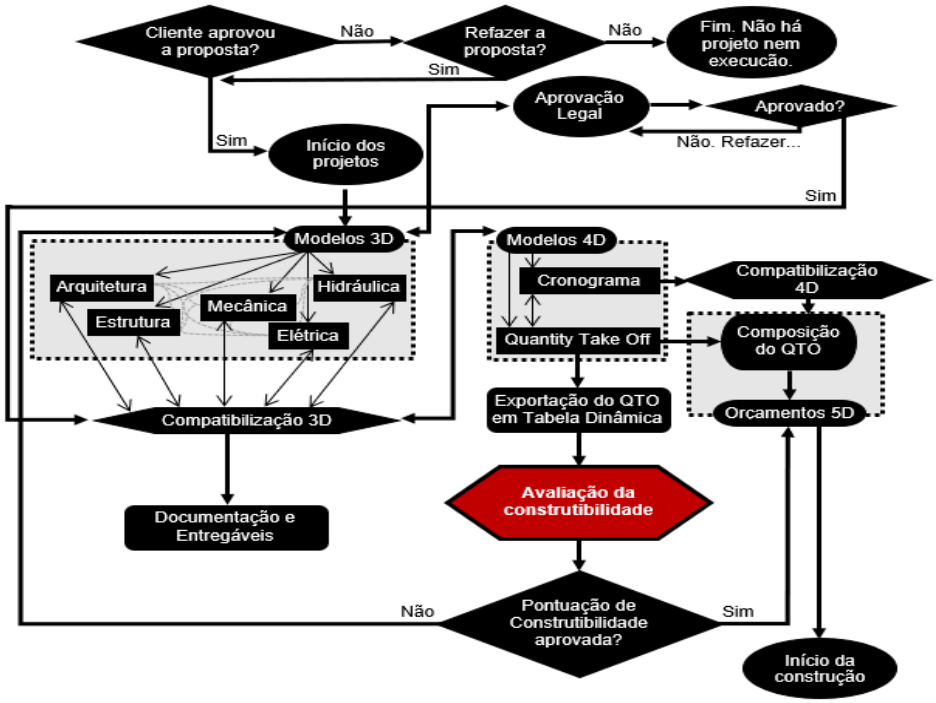

Figure 4. Constructability Assessment in an interdisciplinary BIM system
Note: Source: by the author (2019).

The Constructability Assessment in an interdisciplinary BIM project delivery system, and when it will take place, is explained in figure 4: when the client approves the proposal, the projects begin with the realization of 3D models, with a view to legal approval, the interdisciplinary three-dimensional compatibility and the absence of 3D interferences, the "3D *clashes*." Starting with the compatible 3D model, in addition to the

respective technical documentation, the execution of the 4D Model is also directed. In the 4D Model, tasks are assigned on the calendar and their execution times are compatible, seeking to eliminate time conflicts, "4D c*lashes*," as well as QTO. From the extracted QTO, the 5D Budgets are composed, but the extraction of the quantitative data from the QTO also allows scoring the Constructability Assessment. Once the construction is approved and the budget for the purchasing sector has been released, it is possible to start construction. In this way, the calculation is made possible with automation and fidelity in the extraction of information from the construction model with BIM methods.

With the use of a Constructability Assessment model adapted to the context, a greater propensity for its adoption is created. With the use of tools that take advantage of the construction information in an automated way, its use is facilitated. Moreover, with a deterministic evaluative model, subjective opinions are not incurred, or the lack of a fair balance. Through the basing carried out, the author analyzed 3 Brazilian BIM projects with the proposed methodology, based on the evaluation method used in Asia, and pointed out that the adoption of the Constructability Assessment, prior and deterministic, in BIM projects is possible in Brazil.

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METHODOLOGICAL STRATEGY FOR OPTIMIZATION OF PRODUCTION PROCESSES OF POP MUSIC, BASED ON COMPUTATIONAL MODELS

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Abastract. The design of a methodological strategy consisting of computational models, musical technology and basic rules of harmonic composition is proposed. The strategy integrates different tools such as programming languages, algorithms and reuse libraries for the extraction of strong characteristics from the samples produced by an interpreter, as well as the execution of discrete stochastic processes that execute melodies limited by basic rules of composition of Pop music. generated melodies are converted into series that are later played in a controlled way, by a MIDI device (digital interface of musical instruments) and bounded by musical composition rules that reduce melodic monotony. To specify the integration of all the elements as a system that generates iterations, use open control protocols between programming languages and tools that allow the interconnection and communication between the different technological components that make up the strategy. Once the process of generating melodic fragments is complete, these are transmitted to an audio manager and copied to each channel of the manager in a standard MIDI format. This information, in addition to being editable, provides the producer with the possibility of reusing these tracks as raw material for work to generate greater situations and creative possibilities when developing a Pop music production process.

Keywords: Rules of musical composition, Recovery of musical information, Stochastic Models, Music production, Musical Fragments.

UNA ESTRATEGIA METODOLÓGICA PARA LA OPTIMIZACIÓN DE PROCESOS DE PRODUCCIÓN DE MÚSICA POP, BASADA EN MODELOS COMPUTACIONALES

Resumen. Se propone el diseño de una estrategia metodológica compuesta por modelos computacionales, tecnología musical y reglas básicas de composición armónica. La estrategia integra diferentes herramientas como lenguajes de programación, algoritmos y reutilización librerías para la extracción de características fuertes a las muestras producidas por un intérprete, así como la ejecución de procesos estocásticos discretos que generan melodías acotadas por reglas básicas de composición de música Pop. Las melodías generadas son convertidas en series que posteriormente son reproducidos de forma controlada, por un dispositivo MIDI (Musical Instrument Digital Interface) y acotadas por reglas de composición musical que contribuyen a disminuir la monotonía melódica. Para garantizar la integración de todos los elementos como un sistema que genera iteraciones, se utilizan protocolos de control abierto entre lenguajes de programación y herramientas que permiten la interconexión y comunicación entre los diferentes componentes tecnológicos que conforman la estrategia. Una vez concluido el proceso de generación de fragmentos melódicos, estos son transmitidos a un gestor de audio y copiados en cada canal del gestor en un formato de tipo estándar MIDI. Esta información, además de ser editable, brinda la posibilidad al productor de reutilizar estas pistas como materia prima de trabajo para generar mayores escenarios y posibilidades creativas, cuando se desarrolla un proceso de producción de música Pop.

Palabras clave: Fragmentos musicales, MIDI, Modelos estocásticos, Music Information Retrieval, Reglas de composición musical, SMI

Introduction

Despite the fact that there are innumerable technological tools that support pop music production processes, the flexibility of activities that are part of the development of this type of productions does not stop presenting challenges that must be strictly planned and addressed from a methodological strategy. Problems such as the integration of different computing tools, interaction between applications, generation of editable music content in standard formats, the reuse of strong features extracted from the collections stored in the audio manager, and the transmission of editable data to the digital audio manager, make these challenges can be faced from the use of a plan that generates value to the music production process, and that also involves tools that systematize activities that traditionally consume many technical and human resources.

The creators of this type of sketch are not without challenges when it comes to materializing each creative idea. Activities such as recording sounds and capturing musical instruments are traditionally done with expensive equipment and acoustically designed spaces for capturing voices and musical instruments. It is important to note that after completing some activities, many hours must be spent editing the captured samples, in addition to this, the person responsible for managing the audio manager must have experience in managing this type of project. It is important to mention that on many occasions it is the case that the person who handles the audio manager does not have extensive musical knowledge and this can also limit small projects that do not regularly have a large group of people working in the elaboration of it. All these elements make traditionally consume many technical and human resources in the development of these production processes.

The relevance of developing a methodical plan that guides the integration of different technological tools becomes important when study activities are made more

flexible and alternative technologies to traditional ones are used in the production process. The integration of different tools, connected by means of communication protocols, and the automatic generation of melodic fragments become a support for the music producer, since with the transmission of data represented in instruments, scales, arpeggios and effects in the channels of the manager, the producer is given the possibility to explore different scenarios and settings that allow obtaining different production results. However, the challenge lies in taking advantage of these technologies as a strategic and structured solution within the complex process of pop music production.

Some guidelines to solve problems in sound generation processes or the combination of any of these forms for musical production purposes are described in this section, for example, the proposal of (Thorogood, Fan and Pasquier, 2019) where they seek to reduce costs sound recording, database retrieval and artificial generation of sounds in order to produce soundscapes. In the design of (Turchet and Barthet, 2019) a ubiquitous intelligent guitar system for collaborative musical practice is proposed. The researchers seek the convergence between collaborative and social technological tools that interact within the field of computer ecosystems interconnected on the internet for music, a concept proposed by Turchet et al. (2018). The authors defined this concept as the set of devices interconnected with each other and with computing capabilities to achieve a musical objective. To contextualize the technological concepts discussed so far, we will begin by defining the concept of MIDI protocol on which Rumsey and McCormick (2004, p.97) affirm that it is "a standard for the serial communication of control information between musical devices". Another technology that is part of this proposal is the concept of human-computer devices and, more specifically, intelligent musical instruments (SMI), these elements will be defined as a device with computing characteristics and with the ability to connect to data networks, designed for musical purposes. Digital tools such as audio managers and programming languages are integrated through Open Sound Control (OSC) protocols, a protocol for interconnecting applications, digital musical instruments and computers. Middleware applications are tools for the interconnection between different applications.

By detailing the configuration of this strategy, it can be stated that it is a combination that integrates tools and techniques in order to generate melodic fragments bounded by basic rules of musical composition. These fragments are generated by automated systems that were designed for this strategy. The present proposal is made up of computational models, music technology and basic rules of harmonic composition. The strategy integrates different tools such as programming languages, design and reuse of algorithms and libraries for the extraction of strong characteristics from the samples produced by an interpreter, as well as the execution of discrete stochastic processes that generate melodies bounded by basic rules of music composition. Pop. The fragments generated are converted into series that will later be reproduced in a controlled way by an SMI device. A gradual summary of how each of the parts are integrated can be summarized as follows:

- Perform a sample analysis, extracting the strong features to a digital file.
- Convert scales into vectors and apply permutation techniques.
- Process stochastic matrices and find resulting vectors.
- Make adjustments to the resulting vectors according to basic rules of musical composition.
- Control events in the system through some human computer interface.
- Transmit the results to the manager in an editable format.

Method

Components

To guarantee the integration of all the elements that make up a methodological strategy as a system that generates iterations, open control protocols are used between programming languages and tools that allow interconnection and communication between the different technological components that make up the strategy. Once the melodic fragment generation process is complete, they are transmitted to an audio manager and copied to each channel of the manager in a standard MIDI type format. This information, in addition to being editable, gives the producer the possibility of reusing these tracks as raw work material to generate greater scenarios and creative possibilities, when developing a Pop music production process.

Need for a strategy?

The need to use a strategy that supports and generates value in the elaboration of musical compositions is based on the fact that even for the most inspired musician, the passage of time and the weight of their previous productions, begin to limit their creative capacity. From the 60s and 70s, articles that would be references for research in automatic composition were published: Pattern in Music by Herbert Simon and Richard Summer (1993) and Analysis of Tonal Harmony by Terry Winograd (1968). In particular, Simon and Summer's studies attempt a systematization of the mental processes in the listener, based on the structure of tonal music, applying a rigorous methodology in the processing of information. Some researchers (Hiller, 1979; Inoñán, 2010) have experimented with Markov chains, a simpler and more controllable mathematical model, consisting of a special type of discrete stochastic processes in which the probability of an event occurring depends on the immediately preceding one. In the work of Hori and Sagayama (2016), the researchers make a variation to the viterbi algorithm, generally used to minimize the complexity of playing a phrase on string instruments. The change introduced in the work of these researchers consists of a variation of the algorithm called Minimax Viterbi algorithm in order to minimize movements in the most complex sentences to execute, and maximizing the transition probability supported by models of hidden Markov chains (HMM). A proposal for musical composition based on complex systems, where the author uses chaotic systems for the automatic generation of music, given that "they facilitate the manipulation of the melodic monotony and generate different musical fragments, varying a little the initial conditions of the chaotic system" (Coca, 2009, p.16). A technical summary of this methodological proposal is represented in Figure 1.

Figure 1. Schematic diagram of the methodology for generating melodic fragments.
Note: Source. Author's own creation

Basic rules of harmony

The generation of melodic fragments with a certain discursive coherence is based on a combination of basic rules of musical composition, together with models and computational techniques. The purpose of this set of elements is to parameterize algorithms that partly seek to break the melodic monotony of its own caused by randomness. The rules of musical harmony are treated in this work as a set of equivalences or parameterizations of a system. This compendium of rules has one of its main references in the 1900s with the proposals of Heinrich Schenker and Arnold Schoenberg, considered contradictory, which, however, led to a change that allowed the classification of every chord formed by the superposition of 3 to 12 notes from a bass or root note. Functional harmony is defined as a set of simultaneous notes that generally accompany the melodies, guaranteeing coherence in speech.

Functional Harmony

The concept of functional harmony is the one adopted in this work to establish parameterization rules in a system. According to Galbis (2006): "when we speak of harmony we refer to the vertical aspect of music, the simultaneous sounds that we call intervals and chords and their possible linkages" (p. 50). In the 1900s, according to the Harvard Dictionary of Music (2001), Hugo Riemann invented the term functional harmony in his proposal Theory of tonal harmony (1897), defined as the main note that is called the tonic. This is the main idea that is applied to music composition algorithms, key components of the entire methodological strategy that is developed throughout this work. When on a guitar a musician places his fingers in two or more positions on the neck, he performs the construction of a chord. Chords in their basic construction are determined by rules of functional and traditional harmony, where the central axis of the chord is the tonic and it is accompanied by two more tones that are defined as degrees; a third, known as through, and a fifth known as dominant. These degrees are defined in functional harmony as follow:

- Grade (I) = = Tonic
- Grade (II) = Supertonic
- Grade (III) = Through or Modal
- Grade (IV) = Subdominant
- Grade (V) = Dominant
- Grade (VI) = Superdominant
- Grade (VII) = Sensitive or subtonic

Chord generation

Another important element for the reproduction of melodic fragments are the chords, in the field of harmony they are called the major consonant triad for the chords made up of a major third and perfect fifth; consonant minor triad, made up of a minor third and a perfect fifth, and a diminished triad, made up of a minor third and a diminished fifth. The combination of the above grades in chords of three sounds, composed of two superimposed thirds and constitute the basis of the traditional tonal system. These chords are necessary for the formation of scales and are described as follows: perfect major chord (3rd major + 3rd minor), perfect minor chord (3rd minor + 3rd major), diminished chord (3rd minor + 3rd minor), chord augmented (major 3rd + major 3rd) and major chord with

decreased 5th (major 3rd + decreased 3rd). (Roca and Molina, 2006). The basic configuration of a chord is made up of the root or fundamental tonic note, the third or through and the fifth or dominant, configuration that is called a triad.

When a three-sound chord is played on the tonic of a major scale, a major chord is being played, and in the same way if the musician's performance is on a minor scale, the chord will be minor. The differentiation between one chord and another occurs in the third tone, which, as its own name indicates (through or modal), tells us if the mode is major or minor.

Scales Generation

Another determining harmonic element is the scales, a set of tones that can be simulated in vectors to make their melodic manipulation more flexible and execute with a certain randomness; Depending on the configuration of this vector, major and minor scales can be formed, as well as variations thereof. Assuming the same time scale, twelve values are considered represented in tones and semitones, Harte (2010) represents it in the following set: {C, C♯, D, D♯, E, F, F♯, G, G♯, A, A♯, B}, consisting of the twelve pitch attributes as used in Western music notation. An equivalence of each value in this set of tones and semitones can be identified as a set of integers {1,2, ..., 12}, where 1 refers to the key C, 2 refers to the key C♯, and so on. The way a major scale is defined is a list of seven tones and semitones (T-T-T-S-T-T-T), where semitones make the difference between a major or minor scale. A binary vector is the one that decides the logic of tones and semitones, an example is the vector of ones and zeros "[1,1,1,0,1,1,1]" that represents the major scale where one represents a tone and zero represents a semitone. The vector representing the minor scale would be left with a zero in the third position and in the sixth position “[1,1,0,1,1,0,1]”.

Extraction of strong features

The MIR system that was designed for this project is in charge of extracting the main tone of the sample and then compares the error that the program throws against the tone in which the musical fragment was designed. The basic idea of the algorithm is to find key distances to the main pitch; specifically, perfect fifth intervals, relative major and minor, and major and minor parallel. The MIR system that was designed for this project is in charge of extracting the main tone of the sample and then compares the error that the program throws against the tone in which the musical fragment was designed. The basic idea of the algorithm is to find key distances to the main pitch; specifically, intervals of perfect fifth, relative major and minor, and major and minor parallel see Figure 2.

RELACIÓN CON LA CLAVE CORRECTA	PUNTOS (c_i)
Igual	1.0
Quinta perfecta	0.5
Relativa mayor/menor	0.3
El mismo pero un modo diferente mayor/menor	0.2
Otra	0.0

Figure 2. Relation with correct key.
Note: Source. (https://www.music-ir.org/mirex/wiki/2019:Audio_Key_Detection,2019)

Music composition techniques

The reproduction of melodic fragments must not only be limited by rules of musical composition, musical techniques are also used to structure them. The permutation of musical series is a musical composition technique used since the beginning of the 20th century and called serialism, which was inspired by twelve-tone, another musical composition technique created by Arnold Schönberg and which is based on the 12 tones of the chromatic scale. Among the most recognized composers of the serialist technique are Alban Berg and Anton von Webern (Romero, 2004). This musical technique facilitates melodic manipulation when generating synthesis in a programming language.

Synthesis techniques

A stochastic matrix is formed from the strong characteristics extracted from an audio fragment. The matrices programmed in methods such as a syntactic structure are Markov chains, a specific case of stochastic processes; They are a tool within the field of operations research that allows analyzing the behavior and governance of certain types of stochastic processes.

According to Kolman and Hill (2013), they state that "A Markov chain is one in which the probability that the system is in a particular state in a given observation period depends only on its state in the immediately preceding observation period" (p.119). Each of these chains consists of n states defined in a transition matrix T. This matrix will be generated by a synthesis system specially designed for this work in the ChucK programming language, its creators Kapur and others (2015) define it as: “ChucK is a programming language specifically designed for creating music and sound synthesis in real time” (p.3). In this type of matrix, the probabilities and changes of state are generated by algorithms that are part of this synthesis system. The probabilities of change are represented mathematically as the product of the dimensions that make up this matrix, while the values of the matrix will be generated randomly and cannot be negative. In this proposal an adjustment is made to guarantee that the sum of each row is equal to 1. The arithmetic applied by the algorithms between the stochastic matrices and the musical scales produces vectors that contain melodies already affected by parameters and composition rules. This generalization allows finding all the other state vectors, but to develop this process a series of threads are required, which were built as software components. This system is a logical tool aimed at audio synthesis and composed of modules that interact with each other in order to generate melodic fragments. This tool takes as raw material the patterns or metadata generated in the other recovery system, also designed in the context of this research, this tool is responsible for the recognition of strong characteristics to digital audio samples.

Logical structure of the synthesis tool

The tool aimed at musical synthesis is a design composed of modules that are classes or complex syntactic structures. These structures run on a virtual machine in different threads or synchronized programs running to ensure real-time efficiency. These threads or threads run serially or in parallel. A model that describes this system and its components is represented in Figure 3.

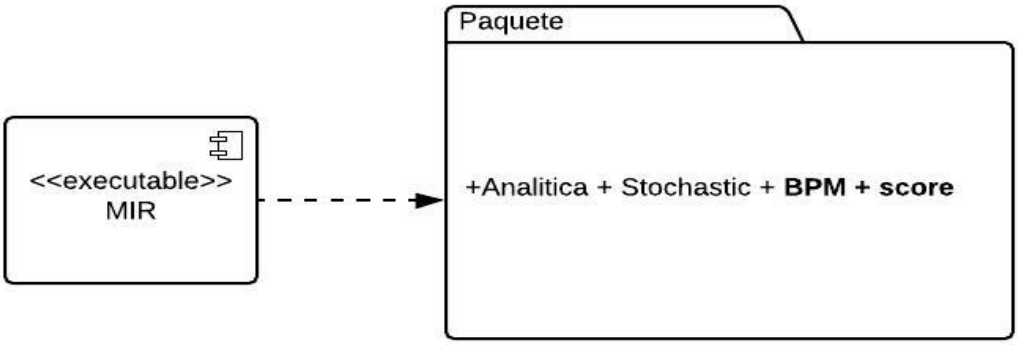

Figure 3. System component diagram.
Note: Source. Author's own creation

A 30-second digital audio fragment is analyzed and as a result it produces a main tone corresponding to a key of a major or minor nature, immediately the methods that execute algorithms within the synthesis system generate major scales, chords, modes, stochastic matrices, filters and vectors.

Classes and methods

A package with four complex structures is developed for the generation of stochastic transition matrices. These matrices are composed of random numbers and meet the conditions required by a matrix of this nature. This syntactic structure, cardinally and communicationally correlated, is the basis for the grouping of the main calculation and generation methods. In Figure 5 the classes, methods and relationships of the syntactic structures that function as directives for all the synthesized instruments that can intervene in the composition of fragments are represented. See Figure 4.

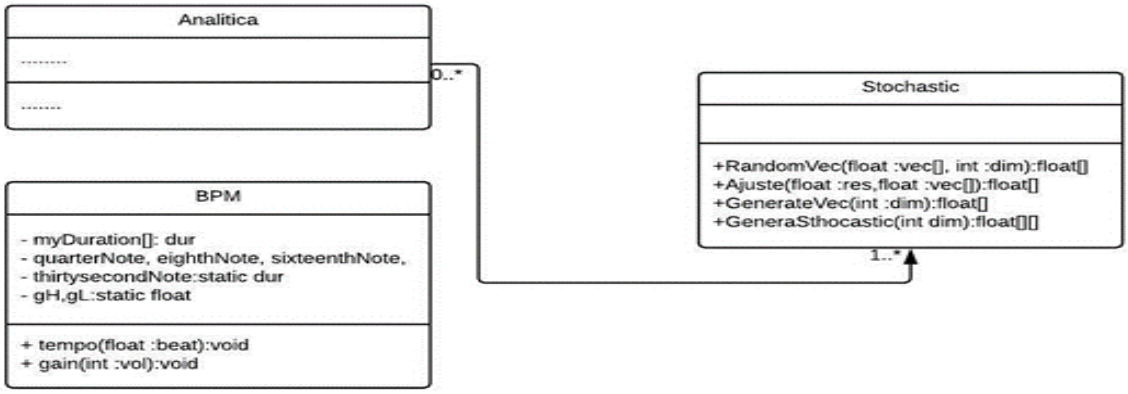

Figure 4. Diagram of main classes.
Note: Source. Author's own creation

A synthesis module executes an orchestrator object that instantiates objects of the generation classes and of a class corresponding to a melodic instrument. Once it is placed in execution, it begins to launch generation methods until writing a melodic and persistent vector, behaving as a database for all the musical instruments of reproduction and different objects in the synthesis system. The following diagram describes the communication between software components when generating a melodic fragment, see Figure 5.

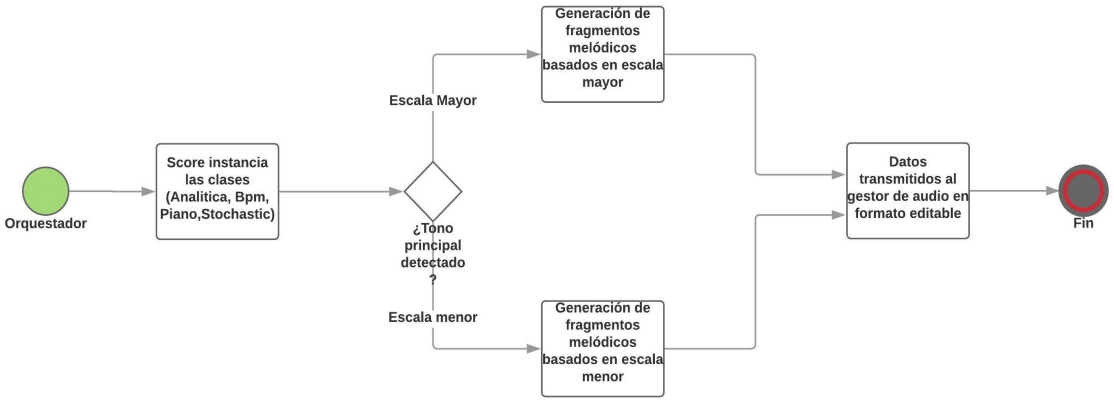

Figure 5. Diagramo of main clases.
Note: Source. Author's own creation

Information contained in the metadata

All the tools previously explained, which interact with each other, work in order to transmit information to a digital audio manager in a standard and editable format. As can be seen in Figure 3, which illustrates the general composition of the strategy, each of these techniques and tools provides important data and information to generate melodic fragments, which must then be transmitted to the audio manager in MIDI and digital audio formats. WAV.

There is communication between the strong feature extraction system and the synthesis system; communication between these two systems is achieved through metadata, and the composition of the file format for the results generated by the different modules of the MIR system is described below, see Figure 6.

Módulo	Archivos	Descripción
Análisis Tonal	Nombre_Key.txt	Tonos presentes en ventanas de
	Nombre_KeyEnergy.txt	Energia de los tonos en ventanas de tiempo
	Nombre_KeyMain.txt	Tono principal
Seguimiento del Beat	Nombre_Beats.txt	Instantes de tiempo de ocurrencia de los beats
	Nombre_Tempo.txt	beats/min
Reconocimiento de Acordes	Nombre_Acordes.txt	Acordes en ventanas de tiempo
	Nombre_Tiempos.txt	Instantes de tiempo de los acordes
Estimación	Nombre_F0.txt	Frecuencias fundamentales en ventanas de tiempo
Frecuencia Fundamental	Nombre_Onsets.txt	Instantes de tiempo de los onsets del audio

Figure 6. Definition of the file format for the results generated by the different modules of the MIR system
Note: Source. Author's own creation

Generation of scales

A set of methods is used for the generation of scales, chords and modes. These algorithms use a vector of ones and zeros that represents the difference between the intervals of a scale, which means that one (1) represents a difference of two positions and a zero (0) a difference of one position, see Figure 7.

Octava	C	C#	D	D#	E	F	F#	G	G#	A	A#	B	
0	0	1	2	3	4	5	6	7	8	9	10	11	
1	12	13	14	15	16	17	18	19	20	21	22	23	
2	24	25	26	27	28	29	30	31	32	33	34	35	
3	36	37	38	39	40	41	42	43	44	45	46	47	{0,1,0,1,1,0,1}
4	48	49	50	51	52	53	54	55	56	57	58	59	
5	60	61	62	63	64	65	66	67	68	69	70	71	
6	72	73	74	75	76	77	78	79	80	81	82	83	
7	84	85	86	87	88	89	90	91	92	93	94	95	
8	96	97	98	99	100	101	102	103	104	105	106	107	
9	108	109	110	111	112	113	114	115	116	117	118	119	
10	120	121	122	123	124	125	126	127					

Figure 7. MIDI positions vs musical NOTES.
Note: Source. Author's own creation

Program logic makes the decision to add a pitch or semitone during the scale generation cycle, while a constant K randomly selects the mode of a specific musical scale. A first method to describe is the generation of major scales, bearing in mind that musical composition rules must be set for major scales. The method developed in this work builds a numerical chain represented in a vector of integer elements, this vector is equivalent to a list of MIDI values positioned according to the classification of the scale found in generation. Describing the generation of a larger scale, this algorithm makes decisions according to the position of the vector that is in initialization. Similarly, the generation method on a larger scale is represented below, see Figure 8.

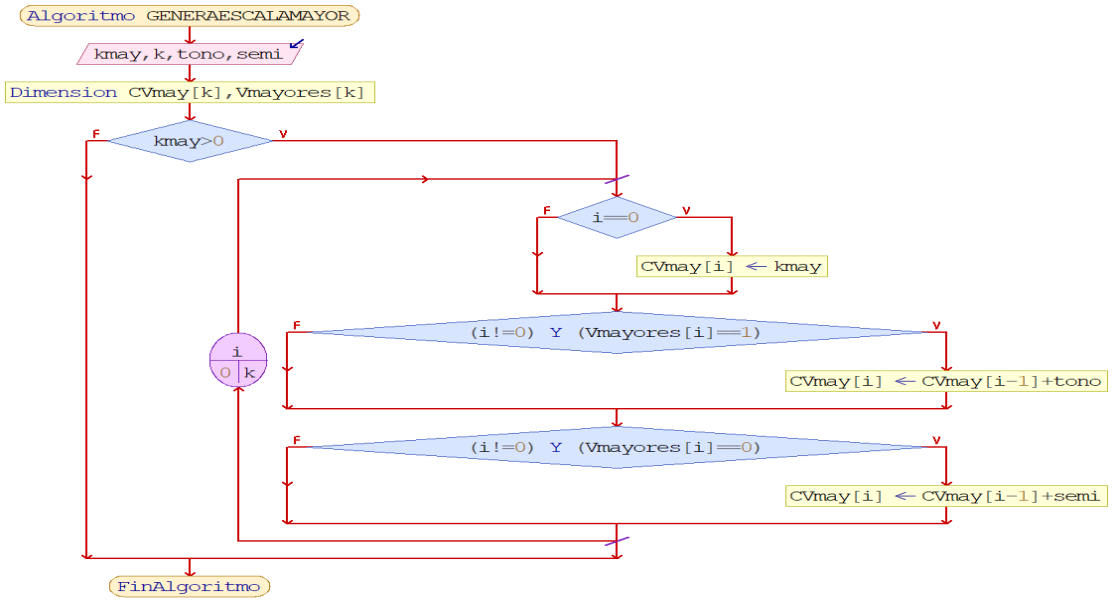

Figure 8. Algorithm for generating the major scale.
Note: Source. Author's own creation

Chord generation and nodes

In the case of major and minor chords, triads are generated made up of the three basic tones to which VII and IX are added, to which the algorithm randomly reproduces with less intensity. This algorithm initializes the value of the pitch depending on the value of each position of a vector. For example, the major scale corresponds to positions 0, 3 and 4 of the vector, which are equivalent to major chords. Positions 1, 2 and 5 correspond to minor chords. Finally, position 6 of the vector corresponds to the diminished chord. In the case of chords corresponding to the natural minor scale, it is important to note that the algorithm for generating these chords initializes the value of the tone depending on the value of each position of a vector. The positions (0,3,4) of the vector are equivalent to the minor chords; the positions (2,5,6) are equivalent to the major chords and, finally, the position (1) of the vector corresponds to the diminished chord. See Figure 9.

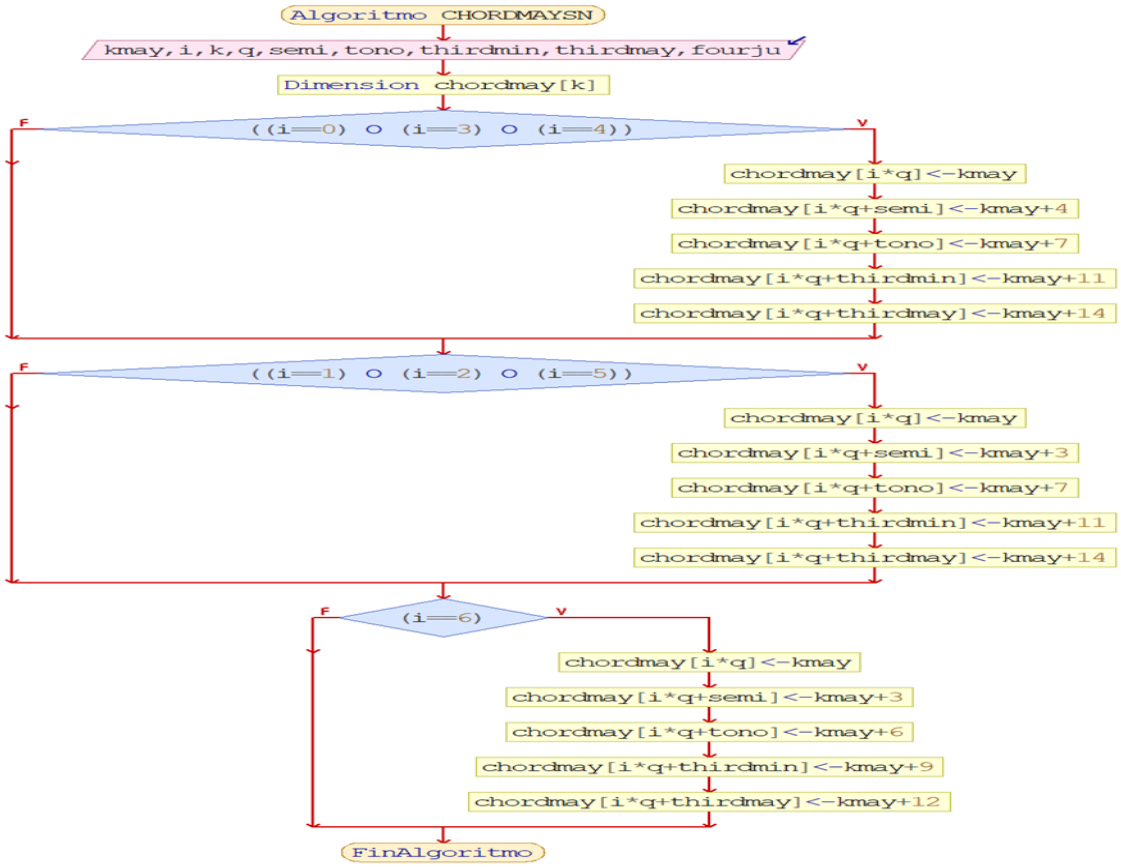

Figure 9. Mode generation algorithm.
Note: Source. Author's own creation

The generation of modes in musical scales is another musical technique that contributes to the recreation of a major or minor scale. Despite the fact that the major and minor scales summarize the characteristics of the modal scales, when recreating the scale or executing its reproduction, differences between a modal context and a tonal context are accentuated Balderrabano (2019). For this case, this algorithm generalizes the modes for the major and minor scales: it basically receives as input data the mode and a numerical interval constant, which corresponds to the summation constant to transport the received scale to each of the modes. See Figure 10.

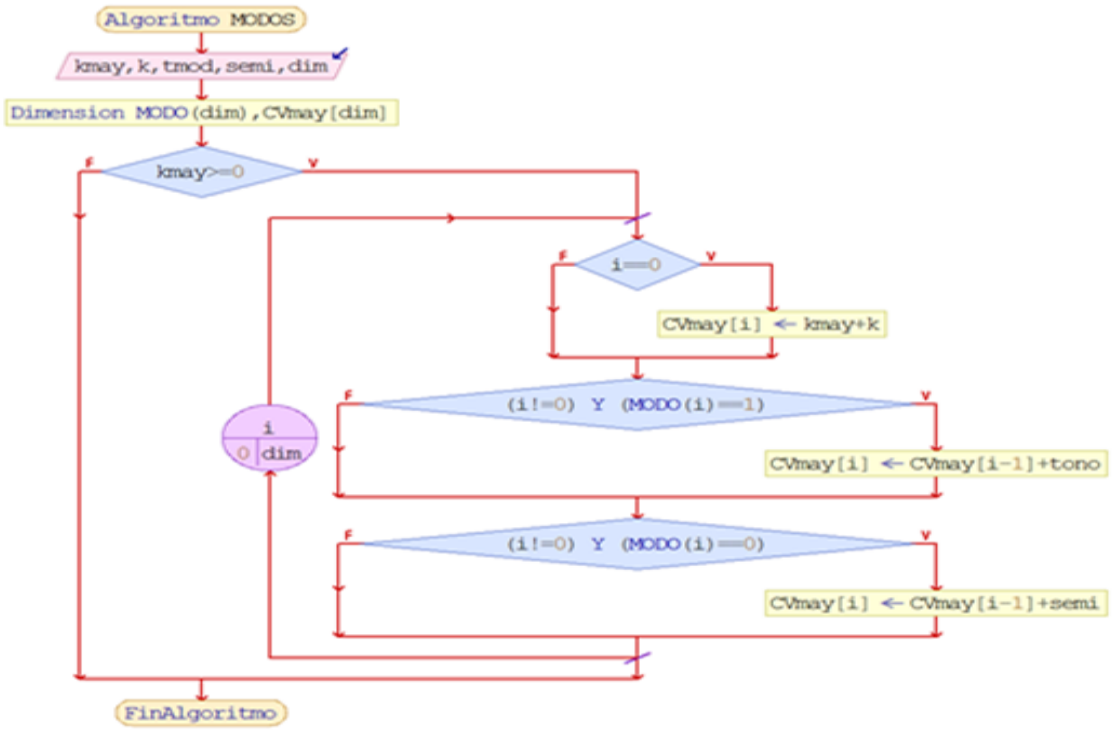

Figure 10. Modal scale generation algorithm.
Note: Source. Author's own creation

Generation of melodic fragments

The generated products are melodic fragments consisting of chords, petriodes, phrases or semi-phrases, which are generated for each time interval, and are divided into intervals that are multiples of the initial time detected for a digital audio sample. For this case and as the algorithms of this work are programmed, the smallest value for each phrase will depend on the detection of the time to the audio sample that the strong characteristics extraction system performs, and on the division that the music performs when time in half notes, eighth notes and sixteenth notes, each figure is a multiple of the fundamental time. Figure 11 represents the sequence of activities, messages and processes until reaching the production process. Once the information is translated by a Middleware software, which works between the programming language and the channels of the audio manager, the information is transmitted until it reaches the editor channels in MIDI data format. The producer edits the data of each channel using the editing and transformation tools of the digital audio manager.

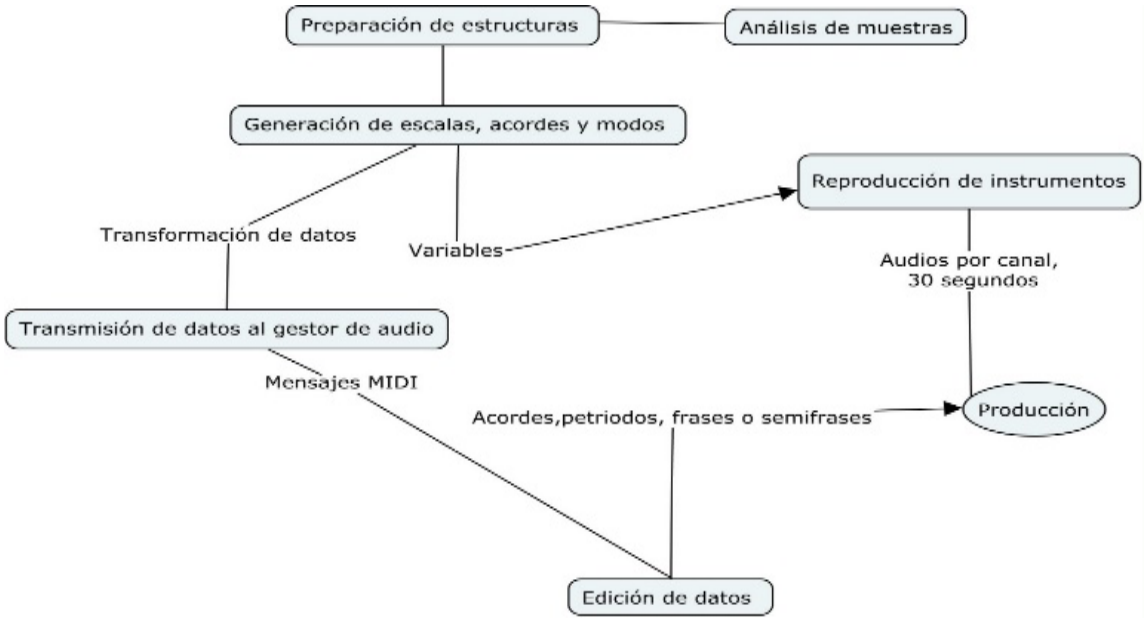

Figura 11. Iteration between processes, activities and messages.
Note: Source. Author's own creation

Data transmission an audio manager

The data transmitted on the channels becomes the raw material for the producer to create, recreate or experience different scenarios. This raw material becomes other intermediate artifacts, such as sound effects, arpeggios, prolongations and everything that creativity and knowledge allow the person in charge of the digital audio manager to edit. The actuation of MIDI devices and human-computer interface devices adds a little more sensitivity to the fragment generated by the computer system. These devices trigger arpeggios and effects that read the information generated by the system, but, in this case, the qualities of these performances depend on the added device and the expressive sensitivity of the player.

Perceptual evaluation of melodic fragments and their simplification

The perceptual evaluation of these melodic fragments requires a tool to collect the opinion of a sample of experts, for this purpose a digital form is designed that collects data and perceptions applied to a population of musicians, producers and engineers, who after listening to the reproductions generated by these fragments, record their perception in a questionnaire that is composed of discrete polytomous variables.

The instruments used to analyze the information collected in the questionnaires are technological tools for data analysis and are consolidated in the current market. For example, the statistical package for social sciences "SPSS", designed by the software house IBM is currently one of the leading applications on the market since the 80s SPSS (2020). Another tool used for analysis of results is the "XLSTAT" package, an application that is installed within the Excel functionalities and is anchored within its own menus using the XLSTAT data sheets (2020).

To analyze and simplify the results recorded in the questionnaire, a multivariate statistical technique is used, in this case the factor analysis technique is used, which is a simplification method in subsets of variables, these subsets represent the most relevant

ratings made by the evaluators. they also identify the variables that the experts considered with the greatest interest.

Elements of the evaluation model

In the musical environment, improvisation is known as the art of producing or conceiving a part of a song or piece, which can be a melody or an arrangement without previously planning, based on some available resources Erkkilä (2000). One of the most popular models for musical evaluation was the one implemented by Swanwick (2002) called CAP (Composition, Audition and Performance), a model that was later adapted by Alberola [20] who made her own version. In this new model, Alberola considered that the essential elements for the evaluation of a musical performance are fluency, sound, posture, notes and rhythm.

The statistical method

In this case, a statistical technique called factor analysis is applied, a multivariate analysis method that has advantages over other statistical methods, since an immense set of data is not necessary to execute data analysis processes finding good reliability measures, also with this The method seeks to explain the variability based on the number of factors that are evident after data processing. This technique also groups variables belonging to each of the relevant factors, and reveals the importance that the respondents confirm of each variable when answering the questionnaire.

Results

In the case of this work, and taking into account that the interpretation is carried out by a computational model, the following proposal is elaborated, consigned in Table 3, where only four elements are included: sound, notes, rhythm and edition. The population of experts who supported the evaluation of this computational strategy was made up of a group of 20 experts: 10 musicians, 5 producers, and 5 engineers, who recorded their opinion in a data collection and perception tool. See Figure 12.

EVALUACIÓN DE FRAGMENTOS MELÓDICOS V 0.0 - 2019
Objetivo: La encuesta que usted diligenciará a continuación evalúa su percepción de un fragmento melódico generado por un modelo computacional, por lo cual es indispensable que sus respuestas sean justas y neutrales. Le solicitamos marcar con una X la calificación que mejor refleje su opinión frente a cada criterio a evaluar, siendo 1=Muy deficiente, 2=Deficiente, 3=Aceptable, 4=Bueno, 5=Excelente.
1.Sonido
a) La reproducción de los sonidos son claros, no confusos y consistentes.
b) Se oyen claramente las distintas alturas y combinaciones de instrumentos.
c) Se oyen claramente los distintos acordes y tonos.
d) La duración de la reproducción de este fragmento melódico es ideal para recrear nuevos escenarios.
2. Notas
a) Los acordes que acompañan a las melodías reproducidas por este modelo computacional son correspondientes y sonoros.
b) Los fragmentos melódicos reproducidos por el modelo computacional son coherentemente discursivos, lo que quiere decir que son coherentes y consistentes en el tiempo que dura su reproducción.
c) El fragmento melódico reproducido por el modelo computacional no es monótono, presenta variabilidad y dinamismo durante el tiempo que dura su reproducción.
3. Ritmo
a) Las notas musicales y acordes se reproducen con ritmo y a tiempo entre los diferentes instrumentos.
b) El fragmento melódico reproducido por el modelo computacional no es monótono en ritmo, presenta variabilidad y dinamismo durante el tiempo que dura su reproducción.
4. Edición
a) La información trasmitida por el modelo computacional es fácilmente transformable y reutilizable.
b) Los sonidos reproducidos por este modelo computacional propician la creación de nuevos fragmentos de canciones o escenarios.
Sugerencias u observaciones:

Figure 12. Melodic fragments evaluation form. Note: Source. Author's own creation

A first analysis carried out on the (N = 20) ratings made by the experts or producers shows that the considerations made are narrowly differentiated, since the values of the standard deviation oscillate between (SD = 0.089 and SD = 0.150), of Similarly, the measurements of the mean oscillate between (M = 3.70 and M = 4.03). Out of a total of (N = 20) cases, none were excluded, nor was it necessary to carry out the elimination of a case, which means that the elimination of a case would not lead to an improvement in the correlation percentages of the data matrix.

Assuming that most of the variables present significant interrelations, it is affirmed that the relationships exist because the variables are common manifestations of "unobservable" factors in a direct way. In this analysis, the aim is to arrive at a calculation

of these factors, summarizing data, clarifying the relationships between the variables and without excessive loss of information (Mahía, 2011). The factor analysis process provides an image of the deep structure of a set of variables to be processed. Once this set of variables is processed, it is optimized to a simpler structure, with fewer dimensions, from which the same information is obtained by generalizing the understanding of the data obtained throughout the sample. In this way, the model is simplified, eliminating redundancies expressed in high correlations between variables, resulting in a set of variables in structural factors. Asensio (2015) states that "factor analysis simplifies the multiple and complex relationships that may exist between a set of observed variables $X1, X\ 2, \ldots\ Xp$." (p. 165).

The summary of cases processed in the present sample yields a good Cronbach's Alpha reliability measure (coefficient used to measure the reliability of a measurement scale). In this case, the measure is ($\alpha = 0.886$), therefore, all of the 20 cases are processed for 11 variables. The results of the reliability test are summarized below in tables. González Alonso & Pazmiño Santacruz (2015) define Cronbach's Alpha as an indispensable indicator to evaluate the degree of correlation between the variables of an instrument. It is also important to highlight that the first two factors explain more than 50% of the total variance. This allows us to affirm that the highest number of ratings made by experts is confirmed in the first two components. See Figure 13.

	Ininiciales	Sumas de las saturaciones al cuadrado de la extracción					Saturaciones al cuadrado de la rotación		
	Total	Varianza	Acumulado	Total	Varianza	Acumulado	Total	Varianza	Acumulado
Compo1	5,247	47,7	47,7	5,247	47,7	47,7	3,124	28,404	28,404
Compo2	1,171	10,645	58,345	1,171	10,645	58,345	1,96	17,817	46,221
Compo3	1,096	9,96	68,305	1,096	9,96	68,305	1,921	17,464	63,685
Compo4	1,008	9,163	77,468	1,008	9,163	77,468	1,516	13,783	77,468

Figure 13. Summary of the explained variance.
Source. Author's own creation

The cumulative sum of the first four components accumulates a total of V = 77.468%, this means that the vast majority of explained variance is contained in these four components. When performing an exploratory factor analysis based on the underlying theory that the factors are independent, Choque (2014) states that: "VARIMAX is a method that seeks to redistribute the variance throughout all the components in the load matrix" (p.103).

The selection of the weights of the variables that make up each factor will be carried out manually, selecting the variable with the greatest weight in each factor. Once the variables with the highest value have been grouped within the matrix, they are highlighted as the subset that makes up each component, as illustrated in Figure 14.

COMPONENTE	1	2	3	4
NOTAS2	0,91	0,199	0,086	0,056
EDICIÓN2	0,79	0,023	0,297	0,329
EDICIÓN1	0,75	0,412	0,307	0,13
SDURACIÓN	0,7	0,323	0,076	0,015
RITMO1	0,5	-0,03	0,414	0,25
NOTAS1	0,19	0,885	0,294	-0,08
SCLAROS	0,38	0,654	-0,06	0,401
SACORDES	0,17	0,6	0,274	0,547
NOTAS3	0,06	0,231	0,864	0,137
RITMO2	0,39	0,128	0,79	0,062
SCOMBINA	0,14	0,07	0,128	0,915

Figure 14. Components formed from the survey.
Source. Author's own creation

Although the results of the factor analysis show the same number of factors as those initially proposed in the evaluation tool, they undergo a new organization and are composed of other variables. These factors show that underlying structure that emerges after exhaustive data processing. The new organization is presented in Figure 15:

Factor 1	Factor 2	Factor 3	Factor 4
X16=NOTAS2	X5=NOTAS1	X7=NOTAS3	X2=SCOMBINA
X11=EDICION2	X1=SCLAROS	X9=RITMO2	
X10=EDICION1	X3=SACORDES		
X4=SDURACION			
X8=RITMO1			

Figure 15. Resulting factors.
Source. Author's own creation

Discussion and conclusions

After a total of six rotations of the data matrix, the total variance explained in all factors tips the balance towards the first factor, where 28,404% is confirmed. This percentage reaffirms in a very important way the possibilities of editing and reuse, given the influence of each of the variables in this first factor of possibilities and flexibility to create new scenarios. This allows us to affirm that this rating is significant and is qualitatively and quantitatively close to what is proposed in the objectives of this methodological strategy. The other factors independently define a variance of approximately 17% for each one, which allows us to conclude that the variables grouped in the first factor were the most relevant for the people who filled out the evaluation instrument. A rearrangement of the variables in each of the factors allows generating a more organized view of the structure that makes up each factor. The evaluation of melodic fragments is grouped into factors, and at the same time each factor groups different variables. In the case of Factor 1, which is the most relevant for making the pop music production process more flexible, the variables that make it up are (X4, X6, X8, X10, X11); Factor 2 evaluates the dimension of clarity and loudness in the different tones and chords, this factor was made up of the variables (X1, X3, X5); Factor 3 evaluates the dynamics in the reproduction of the fragment and was composed of the variables (X7, X9), and Factor 4 evaluates the mix between the different instruments and is only made up of the variable X2. See figure 16.

Factor 1, Posibilidades y flexibilidad	X=Promedio Aritmético, confirma un V=28,404% de la varianza	Categoria
X4	3.7	Aceptable
X6	4	Buena
X8	3.7	Aceptable
X10	3.9	Aceptable
X11	3.8	Aceptable

Figure 16. Resulting factors.
Source. Author's own creation

The design of this methodological strategy allows the integration of different methods and technologies that, when put together, manage to generate editable and reusable information in a different setting than the one proposed in the initial composition by the producer. It is also important to highlight that this micro architecture designed in the synthesis system, allows execution with human-computer interaction devices; devices that, by generating events within the synthesis system, are a more expressive option to the monotony that by its very nature tries to impose randomness.

Chuk being a relatively young programming language with a strong focus on audio synthesis, it does not enjoy strong popularity in many art or engineering schools. For this reason, there is not a huge community of developers in the world that share a wide set of libraries with a mathematical statistical approach. This shortage of free access libraries makes the development of this type of projects using this language longer and more careful.

For the development of this work, it was not convenient to make use of all the strong characteristics extracted from audio samples. By extracting many variants of energy from a sample, from any extraction technique, important close-ups to the original sample are achieved. This situation is not favorable for the objectives of this work, therefore, caution must be exercised with the amount of characteristics extracted.

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SOCIO - TECHNICAL DESIGN OF THIRD LEVEL SERVICES OF PUBLIC HEALTH CARE IN THE CUSCO REGION, PERU

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Abstract. Objective. Determine the proposal to redesign the public health care system of the third level of the Cusco region so that it serves to improve the resolution capacity of hospitals in the treatment of chronic degenerative diseases. Methodology: A qualitative and quantitative approach is used by analyzing the data obtained in the documentary review. Thus, field work is as important as hosting procedural guides. Result: It was found that the redesign of the public health care system of the third level of the Cusco region needs changes that allow the improvement of management; Likewise, it implies the construction of the III-E Specialty Hospital, the Antonio Lorena Hospital remains in category III-1 and the current Regional Hospital becomes the Regional Emergency Hospital in the context of the regional health organizational model based on socio-economic criteria. - technicians. Discussion: References to national hospitals and institutes in the capital are notably reduced, so that the regional public health system becomes a containment ring for the diagnosis and treatment of prevalent non-communicable diseases, thus strengthening the national network. Finally, as a consequence of the study, a theoretical framework is available from which the determinants of health are better explained.

Keywords: Society typology, health transition, epidemiological transition, demographic transition, organizational model, epidemiological profile.

IMPLEMENTACIÓN TÉCNICO – SOCIAL DE SERVICIOS DE SALUD DE TERCER NIVEL DE ATENCIÓN DE LA REGIÓN CUSCO, PERÚ

Resumen. Objetivo. Determinar la propuesta de rediseño del sistema público de atención de salud del tercer nivel de la región Cusco para que sirva para la mejora de la capacidad resolutiva de los hospitales en el tratamiento de enfermedades crónico degenerativa. Metodología: Se utiliza un enfoque cualitativo y cuantitativo mediante el análisis de los datos obtenidos en la revisión documental. Es así que tan importante es el trabajo de campo como acoger guías procedimentales. Resultado: Se encontró que el rediseño del sistema público de atención de salud del tercer nivel de la región Cusco necesita cambios que permitan la mejora de la gestión; asimismo, implica la construcción del Hospital de Especialidades III-E, el Hospital Antonio Lorena permanece con la categoría III-1 y el actual Hospital Regional se convierte en el Hospital Regional de Emergencias en el contexto del modelo organizacional de salud regional basado en criterios socio – técnicos. Discusión: Se reducen notablemente las referencias a hospitales nacionales e Institutos de la capital, de manera que el sistema regional público de salud se convierte en un anillo de contención del diagnóstico y tratamiento de enfermedades prevalentes no transmisibles, fortaleciendo de esta manera la red nacional. Finalmente, como consecuencia del estudio se dispone de un marco teórico a partir del cual se explican de mejor manera los determinantes de salud.

Palabras clave: Tipología societal, transición en sanitaria, transición epidemiológica, transición demográfica, modelo organizacional, perfil epidemiológico.

Introduction

Various aspects currently explain the unusual development of humanity, including advances in digital technology and media that together have generated an accelerated process, in general terms, of reordering the world economy and a cultural alignment around globalization. This accelerated process has become a pattern for many countries to achieve a place in the "global village" through complex mechanisms of assimilation and accommodation.

Another concept that comes from this first reflection is the capacity of States to modulate this transition from both perspectives through the complex mechanisms mentioned and their speed. The modulation of the transition has to do fundamentally with levels of competitiveness and productivity of the population, whose pillars, it goes without saying, are education and health. States that today enjoy economic stability and health welfare are precisely because they have been able to manage the transition with respect to the demands of the new economic, social and political order; while those States in which traditional social, economic and political conflicts prevail, the modulation of the transition shows difficulties in its management.

Several studies have recognized the need to ensure the effectiveness and safety of drug treatments (Alvarez-Risco, Villasante-Herrera and Del Aguila-Arcentales, 2013; Alvarez-Risco, Roman-Calsine and Del Aguila-Arcentales, 2013; Alvare et al, 2013; Enciso et al., 2016; Alvarez-Risco, Quiroz-Delgado and Del-Aguila-Arcentales, 2016; Mejía-Acosta et al., 2016; Silva-Villanueva et al., 2017; Del-Aguila-Arcentales et al., 2018; Alvarez-Risco, Del-Aguila-Arcentales and Diaz-Risco (2018), Alvarez-Risco and Del-Aguila-Arcentales, 2019; Zhang et al.)

In order to focus on the regional health issue and the need for its redesign, it is advisable to centralize the text on the transition and its relationship to health, without this implying that issues are to be avoided, but rather, that they are to be significantly contextualized. Therefore, the concept of health transition implies understanding it within three perspectives that imply transformations: the first one, the trajectory followed by diseases according to the societal dystopias resulting from the determinants; the second one, the prevalence of diseases in certain population niches in certain periods; and the third one, the organized health response capacity on the part of the State to address the trajectories followed by diseases.

Likewise, the capacity of modulation by the State is not limited only to the management of exogenous factors but above all to the preservation of the quality of life as a precondition of habitability, that is, the quality of life derived from the psychological factors that are predecessors of the condition of living, so that a habitable place becomes the physical, psychological and social structure where the population extends its human potential.

However, the evidence on the degradation of the quality of life and habitability in some parts of the world is compelling; The study recognizes that the entropic nature of the universe places humanity in the imprint of chaos and order and knowledge as the mechanism to overcome such imprint, so that education and the level reached by a society is in direct proportion to the quality and habitability of the place it occupies, therefore, the cycles of chaos and order of entropy alternate as the development of humanity and knowledge becomes the mediator of the alternation in order not to put both conditions at risk. A clear example of this is the reaction of the South Korean health system, whose control based on the education of its population has made it possible to reduce the spread of the COVID-19 virus and counteract its effects, unlike other nations. Another component of the theoretical vision of the study consists of challenging the orthodox approaches to health from the general theory of systems including the sociological perspective in order to achieve a totalizing approach. In this sense, the aim is to highlight the causes that are accelerating or not the epidemiological transition and the effects that they cause on the population and its health systems.

Therefore, today, certain economic, social and biological determinants are generating a domino effect on the epidemiological transition, that is, the causes of morbidity and mortality are no longer transmissible diseases such as infections, but those that are not transmissible such as degenerative diseases; re-emerging diseases such as the most aggressive viral processes; and mental diseases such as stress and depression resulting from work pressure and consumption, which require greater complexity and greater resolution capacity in both diagnosis and treatment in hospitals. Regarding the condition on the demographic transition, it is known that degenerative diseases show their prevalence in the elderly population, the re-emergent and mental diseases affect the population in a transversal way.

The public system of national and regional health services has difficulties in facing this new epidemiological profile and challenges its weak capacity to resolve and puts in crisis its system of reference and counter-reference, and above all generates in the population a perception of mistrust of the quality of care and service. In the scenario of emerging epidemiological profiles, it is essential to review the literature on health paradigms and their validity, health care models to see their correspondence, health systems to evaluate their effectiveness, and organizational models on which all systems are based. With these inputs, we propose the redesign of the public health care system of the third level of the Cusco region, to improve the resolution capacity of hospitals in the treatment of chronic degenerative diseases.

For situations of health and disease and their context of occurrence, we begin with the studies on epidemiological transition by Omran et al. (2005) to build a vision of the evolution of diseases on theories that are questionable, but valuable in some topics. In the same way, studies on organizational models, a fundamental part of health systems, are referred to; in this sense, a conceptual demarcation is made with the support of studies from the Tavistock Institute and others; however, special mention should be made of the attempts recognized by supranational organizations such as the World and Pan American Health Organization in matters of health care reform in hospitals in countries such as Brazil, Chile and Argentina with the support of the Technical Cooperation of some countries of the European Community in the framework of the improvement of the operation, management, efficiency and quality of health care provided by hospitals. In this sense, any work that is limited to the above-mentioned objective could not do without the literature generated as a result of this long academic and political debate; in fact, this literature should be included, as far as feasible, in two national sectoral documents on third level health care management in governments.

However, the bibliographic follow-up carried out on the subject in Peru allows us to conclude that there are no important concepts on the improvement of health care in third-level hospitals. This omission is largely due to two factors: first, the seriousness of the situation of the national public health system and the regional debt, and second, the governance crisis that the country has been going through over the last two decades. However, the exquisite debate on the subject within the universities has been verified, but it does not manage to transcend the public sphere. Meanwhile, the negative perception of the public health system by the population continues to grow. In Peru, it is common to see political statements from the government such as the universalization of health care as a fundamental right of the person, but without the company of financing; that the only thing that will be achieved is to aggravate the situation of hospital health care in its three major components: human resources, biomedical equipment and infrastructure. In order to have an adequate perspective on previous research carried out on the improvement of health care management in third level hospitals, access has been gained to the document prepared by bipartite assignment between the Pan American Health Organization and the Technical Cooperation of the French government through the Association for Cooperation in the Development of Health Services, in which health professionals with expertise in development, management and evaluation of health services, human resource management, information systems management and hospital management worked. This team of researchers carried out a study over two years on the transformation of hospital management in Latin America and the Caribbean at the beginning of the century, a crucial moment for global society; whose conclusions should be highlighted because some of them served as a motivation for this study, ergo, continuity to the concepts raised in it; and that at this time it is worth mentioning them.

Method

The methodological approach considers preliminary aspects such as the positioning of the researcher with respect to the reality to be investigated, its qualitative and quantitative approach and its use in the development of the article. The purpose of this approach is for the researcher to assume the methodological development of the article in a dynamic and flexible way, given the relational approach it requires, and attempts to clarify the variety of tools available. Thus, field work is as important as hosting procedural guides. The proposed methodological design is conditioned by factors associated with empirical references and

conceptualizations of the research questions. With respect to the empirical references, it is analyzed to link it to the part of reality that has been observed.

The choice of approach is not only based on the positioning of the researcher, but on the inherent nature of each object and its relationship to the researcher's objectives and interests. So these two options are not exclusive when designing the research methodology. Thus, triangulation as an approach is presented as an option to this polarization, that is, the researcher will be able to collect data with tools from both approaches. Thus, triangulation as an optional approach has the characteristic of being complementary; where qualitative and quantitative approaches feed into each other to produce knowledge that both in isolation could not. The health issue is complex; hence data collection, analysis and interpretation techniques and tools will need to be diverse. The intervention scenarios are not preconceived, but are constructed by the researcher who is the source of the information that he or she will transform into data and allow conclusions to be drawn regarding the research questions. The analysis and interpretation of data is essential; only through this instance can categories, variables and indicators be identified that will allow the objectives of the article to be met. Within the qualitative approach, data collection methods can be available as context and depth to determine the background of people's thoughts and experiences; exploration and discovery, as well as interpretation for an understanding of why things are the way they are.

Results

Epidemiological transition

Health determinants in the Cusco region versus epidemiological profile

Habits and lifestyles are conducive to the transition of noncommunicable diseases; regarding chronic diseases, Table 1 shows that the region is in the national average of chronic diseases with 11.0% and 8.6%.

Table 1

Peru: Standardized mortality rates by cause group per 10,000 population – 2016

Region	Communicable diseases	Tumors	Diseases of the circulatory system	External causes
AMAZONAS	13.8	11.3	23.2	14.3
ÁNCASH	15.0	10.1	11.2	8.9
APURÍMAC	18.9	9.6	10.1	15.3
AREQUIPA	11.8	11.0	7.8	6.7
AYACUCHO	18.4	12.2	8.7	13.4
CAJAMARCA	14.4	12.4	14.9	9.6
CALLAO	12.6	11.0	9.1	2.0
CUSCO	15.6	11.0	8.6	17.7
HUANCAVELICA	16.2	14.3	9.4	14.4
HUÁNUCO	13.8	16.4	10.0	12.2

ICA	14.0	9.2	9.6	4.1
JUNÍN	16.1	13.5	7.9	11.0
LA LIBERTAD	10.9	11.3	12.3	5.2
LAMABAYEQUE	9.8	12.2	9.4	5.0
LIMA	13.0	12.0	8.3	2.6
LORETO	25.2	12.0	9.8	4.7
MADRE DE DIOS	25.5	10.2	7.0	14.2
MOQUEGUA	10.3	12.3	6.5	8.7
PASCO	16.8	14.0	11.2	14.3
PIURA	13.3	11.2	13.9	4.3
PUNO	16.4	7.3	8.6	13.0
SAN MARTIN	17.5	11.7	12.5	11.1
TACNA	13.9	10.9	7.7	7.9
TUMBES	18.5	10.5	17.7	5.0
UCAYALI	22.0	11.8	14.1	7.2
NATIONAL AVERAGE	**15.7**	**11.6**	**10.8**	**9.3**

Note: Source: Ministry of Health (2018)

Epidemiological transition and mortality by cause groups

Table 2 shows that in third and fourth place are the diseases of the circulatory system and neoplastic with 14.63% and 13.64% respectively.

Table 2

Cusco: Mortality by major cause groups 2007 – 2016

N°	LARGE GROUPS OF CAUSES, LIST 10/100		%
1	INJURIES AND EXTERNAL CAUSES	19 186	25.85
2	INFECTIOUS AND PARASITIC DISEASES	12 267	16.53
3	DISEASES OF THE CIRCULATORY SYSTEM	10 860	14.63
4	NEOPLASTIC DISEASES	10 122	13.64
5	DISEASES OF THE DIGESTIVE SYSTEM	7 465	10.06
6	METABOLIC AND NUTRITIONAL DISEASES	3 383	4.56
7	OTHER DISEASES	3 058	4.12
8	DISEASES OF THE RESPIRATORY SYSTEM	2 745	3.7
9	PERINATAL CONDITIONS	2 705	3.64
10	MENTAL ILLNESS AND CNS	2 421	3.26

Note: Source: Ministry of Health (2018)

Epidemiological transition, hospital discharges and reason for consultation

With respect to the epidemiological transition towards chronic-degenerative diseases, the ministry's national discharge report, table 3, shows that the diseases have been showing a prevalence of 21.0%, which includes genital-urinary, cardiovascular, neoplastic, skin and neuropsychiatric diseases.

Table 3

Cusco: Diagnosis of hospital discharges in Diresa's IPRESS 2007 – 2015

N°	LARGEST GROUP, LISTS 12/110	%	AMOUNT
1	COMPLICATIONS OF PREGNANCY, CHILDBIRTH AND PUERPERIUM	23.63	54 961
2	OTHER DISEASES	15.24	35 442
3	DIGESTIVE DISEASES	13.21	30 734
4	TRAUMA AND POISONING	13.00	30 243
5	INFECTIOUS AND PARASITIC DISEASES	12.65	29 418
6	GENITOURINARY DISEASES	7.25	16 860
7	CARDIOVASCULAR AND RESPIRATORY DISEASES	5.27	12 263
8	NEOPLASTIC DISEASES	3.78	8 784
9	DISEASES OF THE SKIN AND THE MUSCULOSKELETAL SYSTEM AND CONNECTIVE TISSUE	2.88	6 691
10	NEUROPSYCHIATRIC AND SENSE ORGAN DISEASES	1.85	4 296
11	ENDOCRINE, METABOLIC AND NUTRITIONAL DISEASES	1.17	2 717
12	DENTAL DISEASES AND THEIR SUPPORTING STRUCTURES	0.07	170

Note: Source: Ministry of Health (2018)

Healthcare transition

Access to health services. Search for healthcare

The requirement for health benefits is linked to an orderly determination of persons. In the first instance, it is determined whether the person who is exposed to a symptom of the illness, experiences an accident or demands a preventive benefit is seeking or receiving the benefits. In the second instance, it is determined to choose a type of benefit provider. These stages are associated with the request for benefits, which determines the number of people seeking benefits or the possibility of accessing a benefit. This perspective of health care services allows finding out who requires the service and who faces accessibility barriers to the service; a situation that will facilitate the design of the focus of the services. Thus, accessibility to health facilities will be highlighted only if the person decides to report sick and be treated in one or another facility. The decision to receive care is conditioned by the fact that the person is on leave of absence as a consumer or by the difference in profits.

On the other hand, it is a priority to take into account the determinants that act in the decision to opt for care in a particular facility, limited to the access to health services and the probability of choosing a particular facility to which one has access. Table 4 shows that in Peru 56.9 percent of the population reported having some form of illness. This percentage is higher when the problem is not chronic (63.8 percent) in relation to chronic diseases (49.3 percent).

Table 4

Peru: Population seeking health care by type of illness. 2015

TYPE OF DISEASE REPORTED		SEEKS CARE		TOTAL
		YES	NO	
CHRONIC ILLNESS	N°	4 914 499	6 060 222	9 964 721
	%	49.3	50.7	100.0
NON-CHRONIC DISEASE	N°	3 920 972	3 930 964	10 851 936
	%	63.8	36.2	100.0
TOTAL	N°	11 835 471	8 981 186	20 816 657
	%	56.9	43.1	100.00

Note: Source: National Institute of Statistics on Informatics (2016)

On the other hand, the evaluation of the relationship between the possession or not of health insurance versus health care provision (Table 5) shows that the situation of the insured person supports the health care provision, and in general the people with health insurance consult their health in a higher percentage than those without insurance in a relation of 58.8% against 53.3%, the provision of health care with EsSalud insurance and others in a relation of 65.4% and 66.2%.

Table 5

Peru: Population seeking health care by health insurance tenure – 2015

INSURANCE AFFILIATION		SEEKS CARE		TOTAL
		YES	NO	
AFFILIATED TO A HEALTH INSURANCE	N°	7 988 533	5 605 708	13 594 241
	%	58.8	41.2	100.0
SIS	N°	3 884 528	3 446 885	7 331 413
	%	53	34.6	100.0
HEALTH	N°	3 310 806	1 750 509	5 061 315
	%	65.4	34.9	100.0

OTHER INSURANCE	N°	775 102	395 917	1 172 019
	%	66.2	33.8	100.0
NO INSURANCE	N°	3 846 938	3 375 479	7 222 417
	%	53.3	46.7	100.0
TOTAL	N°	11 835 471	8 981 187	20 816 658
	%	56.9	43.1	100.0

Note: Source: National Institute of Statistics on Informatics. (2016)

Reasons for not consulting

Table 6

Peru: Reasons for not consulting a health care facility – 2011

	REASONS FOR NOT CONSULTING %					
YEAR	**LACK OF MONEY**	**MISTREATMENT OF STAFF / LACK OF TRUST / DELAY**	**HOME REMEDIES OR SELF-PRESCRIPTION**	**LACK OF TIME**	**WAS NOT NECESSARY**	**OTHER 1/**
2004	23.7	8.3	42.5	9.0	34.3	8.0
2005	24.4	7.9	38.7	9.7	35.1	7.5
2006	21.8	7.9	27.4	10.1	35.0	6.6
2007	22.1	8.6	34.4	12.1	35.1	7.6
2008	18.6	10.3	33.4	14.1	36.2	8.6
2009	15.2	12.0	30.0	17.5	39.2	9.8
2010	13.6	13.1	29.8	19.1	38.5	12.2
2011	12.9	13.6	28.8	18.1	40.5	11.9

Note: Source: Ministry of Health (2018)

The propensity of the causes for which the population that reported illness did not seek care in the period analyzed in table 6 shows a sustained increase in the cause "not necessary" and "lack of time"; the former rose from 9.0% to 18.1%, and the latter from 34.3% to 40.5%. Similarly, the causes linked to the quality of service dimension increased from 8.3% to 13.6%. However, the cause of lack of money has experienced a significant decrease from 23.7% to 12.9%. The same phenomenon occurs with the justification for the use of home remedies, which fell from 42.5% to 28.8%.

Reasons for not consulting according to poverty classified by per capita expenditure

However, the main reason for not consulting is "not necessary" in 40.5% of cases, which was reported in a lower percentage in the extreme poor (32.6%) and in the population of quintile I (31.3%). Lack of money is reported as a cause of nonconsultation mainly among the extremely poor in 21.0% and in the population of quintile V in 9.4%. The use of home remedies is reported as a cause for not consulting in the population of quintile V at 4.8 percent. On the other hand, "self-medication" is the cause that reported the highest percentage in Quintile V, 23.5% versus 13.9%. Inaccessibility to the health center as a cause

of not consulting is higher in quintile I with 10.1 percent and in the extremely poor with 13.8 percent than in quintile V with 0.8 percent and non-poor with 2.4 percent (see Table 7).

Table 7

Peru: Reasons for not consulting a health facility according to poverty classified by per capita expenditure – 2011

		REASONS FOR NOT CONSULTING				
POVERTY		**LACK OF MONEY**	**MISTREATMENT OF STAFF / LACK OF TRUST / DELAY**	**HOME REMEDIES OR SELF-PRESCRIPTION**	**LACK OF TIME**	**WAS NOT NECESSARY**
POOR EXTREME	N°	158 015	93 653	266 856	81 215	244 910
	%	21.0	12.4	35.5	10.8	32.6
POOR NON-EXTREME	N°	532 198	407 406	816 816	450 882	918 002
	%	19.8	15.1	30.3	16.7	34.1
NOT POOR	N°	901 968	1 178 814	2 459 520	1 697 973	3 826 234
	%	10.2	13.3	27.7	19.1	43.1
QUINTIL I (POOREST)	N°	492 815	399 771	902 235	364 579	808 585
	%	19.1	15.5	35	14.1	31.3
QUINTIL II	N°	468 845	410 086	754 461	481 314	912 313
	%	18.2	15.9	29.3	18.7	35.4
QUINTIL III	N°	337 009	369 899	658 258	511 383	1 070 086
	%	13.0	14.3	25.5	19.8	41.4
QUINTIL IV	N°	218 945	297 027	613 336	508 319	1 069 844
	%	9.1	12.3	25.4	21.1	44.4
QUINTIL V (LESS POOR)	N°	74 567	203 188	614 902	364 476	1 128 318
	%	3.4	9.4	28.3	16.8	51.9
TOTAL	N°	1 592 181	1 679 973	3 543 192	2 230 071	4 989 146
	%	12.9	13.6	28.8	18.1	40.5

Note: Source: Ministry of Health (2018)

Inequality analysis

The Lorenz curve and the Gini index make it possible to determine the existence or not of inequality in the distribution of the population that reports illness, globally and according to type. In the same way, it shows the inequality in access to institutional care. To achieve this purpose, we work with the Gini index, the concentration index and the multiple linear regression. The Gini index is used to assess the distribution of income among the population. This index is based on the Lorenz curve and the accumulated frequency curve, which contrasts the empirical distribution of a variable with its uniform distribution of

equality represented by a diagonal line. The greater the area between the Lorenz curve and the diagonal, the greater the inequality.

In fact, the curve can be below or above the diagonal, depending on the variable used. Precisely, one of the ways to measure the degree of inequality in the Gini index is to summarize the deviation of the Lorenz curve from the equality diagonal. This index is twice the area between the Lorenz curve and the diagonal and takes values between zero which corresponds to perfect equality and one which is total inequality. The study analyzes how the distribution of health problems is concentrated according to their nature and how access to health care is distributed. For 2011, Peru's Gini index for those who suffer from a disease is 0.305.

When prospecting according to the type of health problem, a greater inequality in the distribution of people who suffer from an acute illness according to Gini corresponds to 0.89 than if they had a chronic health problem 0.638. In relation to the distribution of access to health care in institutional centers, there is an index of 0.86 that shows a pattern of inequality. Table 69 of the evolution of the Gini index assesses the propensity to inequality measured with this index in the period 2004 - 2011. A decrease in the inequality of the distribution of the declaration of some disease symptom is observed. Thus, for the year 2004 the inequality is 0.64 and for the year 2011 it decreases to 0.305. This behavior is similarly observed in the inequality of the distribution of people suffering from a chronic disease from 0.823 in 2004 to 0.633 in 2011.

In relation to people who have reported an acute illness, the inequality measured with Gini has remained above 0.8 during the period 2004 - 2011. Inequality in the distribution of access to health care in health centers has also remained above 0.8 since 2004. Therefore, this first approximation shows that health problems are unequally distributed, emphatically those of an acute nature and in the access to institutional health care. Therefore, it is necessary to demonstrate whether the inequality is produced by economic factors and for that purpose the concentration index.

Evolution of expenditure in the health sector

In relation to the evolution of health spending as a percentage of the Gross Domestic Product in the period 2000 - 2014, it is concluded that there is a favorable trend in the sector, which went from 2.68% in 2000 to 3.32% in 2014. However, the budget allocated is still insufficient if we take into consideration those allocated in countries of the region such as Colombia and Chile and others of the Organization for Cooperation and Development. According to table 8, the evolution shows that by 2014 it will account for 3.32% of the Gross Domestic Product and the average for the region is 7.2% and the average for the countries of the Organization was 12.4%.

In the context of the health transition, what was analyzed in the previous paragraph leads to think about the insufficiency of the budget to finance the public health care model already questioned, so that its objective is basically to finance the Essential Plan for Universal Insurance (PEAS) and not to improve the sector as a whole, with the deficiencies that this implies with respect to the effectiveness of the expenditure, because according to the Demographic and Family Health Survey (ENDES) the population with coverage is smaller than the population informed by the program; Another situation is due to the fragmentation of the health service; and to this is added the uncertainty generated by strategic programs at the time of planning. With respect to the present study, it is necessary to specify the emphasis that the State places on the quantitative situation in detriment of the quality of attention.

Table 8

Peru: Evolution of health spending as a percentage of GDP

PERU: EVOLUTION OF HEALTH EXPENDITURE AS A PERCENTAGE OF GDP			
	PERCENTAGE		
YEAR	PRIVATE EXPENDITURE	PUBLIC EXPENSE	TOTAL EXPENSE
2000	2.08	2.68	4.76
2002	2.10	2.81	4.91
2003	1.92	2.70	4.62
2004	2.02	2.54	4.56
2005	1.99	2.65	4.65
2006	2.01	2.37	4.36
2007	2.16	2.41	4.58
2008	2.30	2.50	4.77
2009	2.39	3.00	5.39
2010	2.26	2.80	5.08
2011	2.29	2.60	4.91
2012	2.33	2.85	5.17
2013	2.19	3.05	5.23
2014	2.15	3.32	5.47

Note: Source: Ministry of Health (2018)

In relation to the density of human resources per inhabitant, table 9 shows that the ratio of health care personnel, that is, doctors, nurses and obstetricians, per every ten thousand inhabitants has been growing progressively and proportionally in the period 2012 - 2018 with a slight increase in the growth of nursing personnel, in the perspective of going beyond the World Health Organization's fence. According to the World Bank, only five out of forty-nine countries classified as low-income manage to surpass the threshold of 23 doctors, nurses and midwives per ten thousand inhabitants, a figure that the World Health Organization has set as the minimum necessary to provide essential maternal and child health services. So those countries that do not surpass this fence have difficulty providing basic health services.

With respect to the expenditure on health per capita in 2016, the World Bank published a summary of expenditure by country. The data shows that the United States is the country that invests the most in health per capita in 9,869.74 dollars and at the opposite end is the Central African Republic with 16.36 dollars. In the European region, spending fluctuates between US$ 9,835.96 and US$ 2,389.89; while in the Latin American region it fluctuates between US$ 1,379.10 (Uruguay) and Nicaragua with US$ 188.16, Peru invests US$ 316.44 in health per capita, long surpassed by Chile, which invests US$ 1,190.55.

Table 9

Peru: Human resources density in health per 10,000 inhabitants

	2012	2013	2014	2015	2016	2017	2018

MEDICAL	11.3	11.5	11.9	12.2	12.7	12.8	13.6
NURSE	11.2	11.8	12.7	12.8	13.5	14.1	15.6
OBSTETRA	3.9	4.1	4.7	4.6	4.8	5.0	5.3
TOTAL	**26.4**	**27.4**	**29.3**	**29.6**	**31.0**	**31.9**	**34.5**

Note: Source: Ministry of Health (2018)

The World Bank established the number of doctors per inhabitant, determining, according to the countries of the world, the varied relationship that shows the interest of each country in health. Thus, there are countries such as Afghanistan with a ratio of 0.3 per 10,000 inhabitants and, in extreme contrast to Germany with 4.0, Peru has 1.3 doctors per 10,000 inhabitants. According to the 2005 census, Peru has a ratio of 10 physicians per 10,000 inhabitants. If the Latin American average of 21.6 is taken as a reference, Peru is below half the rate.

Discussion and conclusions

The Cusco region through the Directorate of Health has demonstrated deficiencies in the management of basic strategic programs; its indicator of malnutrition and anemia is increasing, which puts on alert more complex situations such as the management of diagnostic diseases and complex treatment as degenerative pathologies, and eventually endemic or pandemic health situations. Thus, academic events, access to Internet forums, and the globalization of information itself provide enormous opportunities for access to knowledge that will help to understand the problems that other countries have experienced or are experiencing, and to understand in a broader context the occurrence of diseases and to eventually undertake solutions.

An inconvenience detected in the protocol of health provision for chronic-degenerative diseases in the Regional Hospital of Cusco revealed that the problem was not superficial, it was just the tip of the iceberg, it had a structural origin that in a systematic and sustained way was becoming more acute. The problem of the regional and national public health system has been atomizing and with it eventual solutions have been dissipating and losing their effectiveness as a consequence of the growing complexity of the diseases and the anachronism of the health system.

The first result consists of levels as described below. Firstly, the implicit notion of a structure based on the general theory of structures in its two aspects, from the perspective of Bertalanffy or objective theory, and that of Luhmann or sociological theory. The second refers to the concepts of the human condition and its relationship with habitability and entropy. Thirdly, health in the scenario of habitability; finally, and central to the result, the concepts of health itself, such as the transition in health understood from its three subsequent transitions: epidemiological, sanitary and demographic; organizational models in health systems, and health paradigms.

Thus, today there is a theoretical framework that explains with relative clarity the context of the health problem and the challenges faced by the ministry of the sector. The study demonstrates the conditioning that occurs between the determinants of health and the transition of diseases; it shows how inadequately the State is organized to manage the epidemiological profile, and how certain population niches are vulnerable to certain diseases. The global vision of the health problem built on the foundations mentioned above will allow those directly involved to assume their functions and competencies in the context of the redesign of the regional public health system with the autonomy recognized by law, and in coordination with the national system.

The study determined, based on statistical data and respective reports, that special attention should be paid to the fact that hospitals base their service portfolios on the demand for services and not simply on criteria of functionality. In this regard, the study specifies two fundamental aspects to propose the redesign of the public health system. The first one is that the national referral and counter-referral system is in crisis and that the obtaining of quotas in national hospitals or institutes in the capital to refer patients with reserved diagnoses is prolonged so that the provision of health care is not timely. The second, that the prevalence of noncommunicable diseases with complex diagnosis and treatment does not have the adequate resolution capacity, that is, the quality of the hospital infrastructure is questioned, the quality of the biomedical equipment, and finally, the human resource is not properly trained. Obviously, the study focuses its interest on investigating the epidemiological and demographic transition, as well as societal typologies and to demonstrate that the prevalence of nontransmissible and re-emerging diseases are those that have been affecting the population, so that the public attention system must be redesigned to be within the reach of the population. In that sense, the redesign of the public health care system of the third level of the Cusco region implies the construction of the Specialties Hospital III-E, the Antonio Lorena Hospital remains with the category III-1 and the current Regional Hospital becomes the Regional Emergency Hospital, in this way the references to national hospitals and Institutes of the capital are reduced notably, so that the regional public health care system becomes a ring of containment of the diagnosis and treatment of prevalent noncommunicable diseases, strengthening in this way the national network.

With respect to the specific objectives these have been fulfilled with the necessary evidence according to the following detail:

The study found that the disorganization in the provision of the service of the regional public health system is due to the hospital organizational model that generates a negative perception of the service as a consequence of the bad provision and in the delay of this one as it indicates the model of linear regression for the predictor of population that does not look for attention for delay in the attention and the model of linear regression for the predictor of population for lack of confidence. Another disorganizing aspect of the system is the proportion of physicians per inhabitant, which is below the international standard, as demonstrated by the Pan American Health Organization. The budget gap has been increasing every year to the point that it puts the health system's operations at risk; in this regard, it has been demonstrated through a review of the personnel assignment table that those in charge of budget requirements do not have the necessary professional qualifications, the procedures manual is not explicit and in general there is no involvement of workers in the labor functions.

The study showed that the causes of nonconsultation in health facilities due to chronic disease are due to the poverty levels of the population classified by per capita expenditure, the location of the health center according to urban or rural environment, functional literacy, health insurance ownership, family violence, human development index, migration and urbanization processes, and access to basic services. However, a determining aspect that was addressed in the study refers to the lifestyle and consumption habits that come as a result of the globalization spread through the media.

In relation to the fifth and last specific objective of determining the deficiencies of the state's insurance system affecting the accessibility of health treatment in hospitals in the Cusco region, the study has verified that the population's subsidized health care reaches expected levels of coverage, that is, that the joint insurance system tends to cover one hundred percent of the population, and that the health care package of the comprehensive health insurance is no longer basic but also covers chronic degenerative diseases.

Conclusions

Lack of previous research studies in the region

The study was limited by the fact that there are no research studies specifically related to the health transition in the Cusco region, that is, the three transitions are analyzed together; and specifically the health transition that made it difficult to fulfill the objective of identifying the causes that motivate the "non consultation" due to chronic disease; on the other hand, the regional health situation analyses do not systematically focus on the deficiencies of the organizational model of which they are a part, and which motivates the population not to go to hospitals.

Lack of available and/or reliable data

The law regulates the elaboration of the health situation analysis in hospitals (ASISHO) every four years; so that the information it shows allows the identification of the tendencies in the health indicators and to propose alternative strategies of delivery; this information should allow the identification of the phase of epidemiological transition in which the region is; the hospitals of the region do not have this document; therefore, the lack of specific data is a limitation.

Recommendations or prospective

It is recommended to persist in research works referred to the sanitary transition with the purpose of deepening in data about the deficient situation in which the regional hospital organizational model is found, which prevents people from having a positive perception of the health benefits of the public system that affects the population with chronic-degenerative disease. It is emphatically recommended to carry out research work to strengthen the first level of care alternatively. In a preliminary way, the study has demonstrated the need to invest in hospitals of greater complexity in the region to attend to increasingly complex communicable diseases; but it is also necessary to control diseases in the prevention and early diagnosis phase.

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SUCCESS FACTORS OF MSMES IN THE HEALTH SECTOR, CITY OF HUANCAYO - PERU, 2020

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Abstract. Introduction: The concept of business success is broad and there is no consensus on its measurement. The most widespread trend is to use financial indicators such as profitability, productivity and sales growth. In the city of Huancayo, Peru, at the beginning of 2020, there are 381 MSMEs (micro, small and medium-sized companies) in the health sector. The objective of the investigation was to determine the factors for the success of the MSMEs in the Health Sector of the city of Huancayo, using an econometric model. Methodology: The hypotheses to demonstrate were that the source of financing, strategic planning and the use of ICTs, management training, innovation, the application of a quality program, dedication to business and advertising on social networks have an effect significant in the success of these companies. The investigation was non-experimental explanatory, developing an econometric model using the multiple linear regression method. The dependent variable was numerical, the dichotomous qualitative independent variables (dummies). The universe was considered for the study (census). Results: The econometric model obtained an $R^2 = 0.463$ (it is close to a statistically good value) and a significant F, it also fulfilled the linear regression assumptions, thus being validated. Discussion: For this model, the source of financing, strategic planning and the use of ICTs, managerial training, innovation, dedication to business and advertising on social networks were significant for the model. However, the application of a quality program was not statistically significant, therefore, it was discarded from the model.

Keywords: factors, business success, MSMEs, health sector.

FACTORES DE ÉXITO DE MIPYMES DEL SECTOR SALUD, CIUDAD DE HUANCAYO – PERÚ, 2020

Resumen. Introducción: El concepto sobre éxito empresarial es amplio y no existe consenso sobre su medición. La tendencia más extendida es utilizar indicadores de tipo financiero como la rentabilidad, productividad y crecimiento de ventas. En Huancayo, Perú, a inicios de 2020, existen 381 Mipyme's (micro, pequeñas y medianas empresas) del sector salud. El objetivo de la investigación fue determinar los factores

para el éxito de las Mipyme's del Sector Salud de la ciudad de Huancayo, usando un modelo econométrico. Metodología: Las hipótesis a demostrar fue que la fuente de financiamiento, la planificación estratégica y el uso de TIC´s, la formación gerencial, la innovación, la aplicación de un programa de calidad, la dedicación al negocio y la publicidad en redes sociales tienen un efecto significativo en el éxito de estas empresas. La investigación fue explicativa no experimental, desarrollándose un modelo econométrico mediante el método de regresión lineal múltiple. La variable dependiente fue numérica, las variables independientes cualitativas dicotómicas (dummies). Para el estudio se consideró al universo (censo). Resultados: El modelo econométrico obtuvo un $R^2 = 0.463$ (cercano a un valor estadísticamente bueno) y un F significativo, cumplió además con los supuestos de regresión lineal, siendo así validado. Discusión: Para este modelo, la fuente de financiamiento, la planificación estratégica y el uso de TIC´s, la formación gerencial, la innovación, la dedicación al negocio y la publicidad en redes sociales, resultaron significativas para el modelo. Sin embargo, la aplicación de un programa de calidad no resultó estadísticamente significativa, por tanto, fue descartada del modelo.

Palabras clave: factores, éxito empresarial, Mipymes, sector salud.

Introduction

The success or performance of the company is a broad and heterogeneous concept and there is no clear consensus in the literature regarding its form of measurement (Estrada, García, & Sánchez, 2009). The most widespread trend is to use financial indicators such as profitability, productivity and sales growth. The studies that can identify the behavior of the determinants of the success of MSMEs may serve as guidance to achieve an adequate consolidation of these businesses, business success and the economic benefit of their owners. The health sector, at present, is one of the areas that is being developed the most in the private service company. Huancayo has become an attractive place for this type of company. By identifying the success factors for the micro, small and medium enterprises of the health sector of the city of Huancayo, theoretical approaches would be provided for their progress, which may have better profitability, greater probability of survival and avoid their failure. The objective of the thesis was to determine the factors for the success of the MSMEs of the Health Sector of the city of Huancayo, by means of an econometric model. For this, factors were taken into consideration as the source of financing, strategic planning and the use of ICTs by the company, managerial training, innovation, the application of a quality of care program, dedication to the business of the entrepreneur and social media advertising. (Rocca, 2017).

MSMEs

The term MSMEs involves three different types of companies: micro, small and medium, and they constitute approximately 99.6% of formal businesses that exist in Peru; although they are included within the same category, each one has its own characteristics, which differentiate them from other business models (Certus, 2019).

Microenterprises

One of the main criteria used to differentiate the types of companies is the average annual sales. Microenterprises should not exceed 150 UIT for this concept (UIT = Peruvian Tax Unit, according to the Peruvian Tax Code, it is a reference value that can be used in tax regulations, among others); likewise, they are characterized by having between 1 to 10 workers on the payroll. Many family businesses adopt this business model, since, in principle, it does not require a very large capital investment (Certus, 2019). For this reason, they constitute good development opportunities and are becoming

increasingly important within the economy. One UIT is equivalent to S/. 4,300 ($ 1,228.50) in 2020.

Small enterprises

A small company in Peru receives between 150 and 1,700 UIT in terms of annual sales. The number of workers can vary from 1 to 100. Some businesses that are usually included in this category are medium-sized restaurants, hairdressers, veterinarians and hardware stores. Currently, in Peru there are more than 50,000 small companies, which are undoubtedly an important source of job creation (Certus, 2019).

Medium enterprise

Finally, the medium-sized company differs by having annual sales greater than 1,700 UIT and less than 2,300 UIT. Given that they operate with a greater number of workers, it can be said that it is a much more complex business model, in which a more sophisticated level of organization is required (Certus, 2019).

Business Success

Rocca (2017, p. 58), in a study carried out in Peru, cites that:

> The success or performance of the company is a broad and heterogeneous concept and there is no clear consensus in the literature regarding its form of measurement (Estrada, García, & Sánchez, 2009). The most widespread trend is to use financial indicators such as profitability, productivity and sales growth; however, these measures have the difficulty that companies are reluctant to share this type of information. For some authors, performance measured qualitatively can show more objectively the profitability of the company (Zahra, Neubaum, and Naldi, 2007; Okamuro, 2007).

Previous studies

In the research work carried out by Rocca (2017), the following findings were reported:

There are factors that constitute important implications for different entities linked to the business environment. In this research on the success factors of MSMEs, this variable was measured as a level of performance using a 5-point Likert scale (1 = total disagreement and 5 = total agreement) to define whether the company compared to its competitors: a) is growing more; b) is more profitable; and c) is more productive. To verify the reliability of this scale, Cronbach's alpha was determined, which obtained a value of 0.779. The results showed that MSMEs that have more developed management control systems in place and that apply more efficient human resource management practices, the greater the probability of being successful in the market. The results are especially useful for the managers of the MSMEs and the organizations that promote MSMEs so that they can design and promote strategies and policies that favor the growth and competitiveness of the MSMEs.

In the study carried out by Vílchez (2016), the following results and conclusions were reached:

That economic development, more than being a phenomenon of economic growth, includes aspects such as income distribution, health, food, housing and others. According to various authors, the microenterprise generates economic development. If this is successful, the family of the microentrepreneur reaches greater development. The hypothesis to be demonstrated was that financing through financial entities and the

formalization of microenterprises, as well as management training, entrepreneurship, business spirit and dedication to the business of the microentrepreneur, favor the economic development of the families of the microentrepreneurs in Huancayo. The research was of a non-experimental explanatory type, developing two econometric models using the multiple linear regression method. The sample was 379 microentrepreneurs. The econometric model, about the determinants of economic development, obtained an $R^2 = 0.57$ (statistically good) and a significant F, also met the assumptions of linear regression, thus being validated. For this model, management training, formalization, entrepreneurship, business spirit and dedication to the business were statistically significant; however, the source of financing did not turn out to be of the importance that a priori was raised.

Rivera (2016), cites that:

Today's world is characterized by the globalization of markets, the internationalization of economies, accelerated technological development, rapid changes and the flexibilization of labor relations. The results of the research specified the most important variables of the data series collected to carry out the analysis of the profile of the Ambato entrepreneur and the determining factors of his survival. Five characteristics framed in competencies were identified: individual psychological, collective psychological, cognitive, axiological and environmental factors, as characterization variables of Ambato entrepreneurs.

Method

Design

For the present study, an econometric model was formulated through the multiple linear regression method; which allows investigating the relationship between several independent variables with a dependent one. A mixed, descriptive and explanatory investigation was carried out. The research design was non-experimental. The proposed econometric model was the following:

$$\mathbf{Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \mu}$$

Where:

Y = Éxito de la MIPYME

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ = coeficientes de regresión

x_1 = fuente de financiamiento de la Mipyme

x_2 = planificación estratégica de la Mipyme

x_3 = uso de TIC's por la Mipyme

x_4 = formación gerencial del empresario

x_5 = innovación del empresario

x_6 = implementación de un programa de calidad de atención del personal de la Mipyme

x_7 = dedicación al negocio del empresario

x_8 = publicidad de servicios a través de redes sociales

α = constante

μ = error aleatorio

Variables

The dependent variable (Y) was of a quantitative type and the independent variables (x_j) were of a qualitative nominal dichotomous type (dummies), assigning the value of 1 when the factor is present and 0 when it is absent.

The Success of the MSME, which was a quantitative interval variable, was measured through the entrepreneur's appreciation of the performance of the MSME, considering three aspects (dimensions): growth, profitability and productivity. For the rating of each dimension, the 5-point Likert Scale (1 = poor development, 2 = fair development, 3 = good development, 4 = very good development and 5 = excellent development) was used for each dimension. The success of the company was measured by the total sum score of each dimension.

The independent variables were:

Source of financing for MSMEs

The sources of financing of the company are the ways that the company uses to obtain the necessary financial resources to pay for its activity. The sources of financing will be the channels used by the company to obtain funds. (Andrade, 2017).

Strategic planning of MSMEs

Strategic planning is the management process that allows organizations to define and establish the objectives to be achieved, as well as the activities that will be carried out to achieve them. (Pérez, 2016).

Use of ICTs

ICTs (Information and Communication Technologies) refer to the group of technological advances that have been developed to manage information and share it from one place to another (Pacheco, 2017)

Management training of the entrepreneur

Necessary tools for the design and application of them in an organized, planned and sustained process in the approaches, an effective system and objective of performance evaluation (Sierra, 2016).

Innovation

It is the degree to which a social system in advance uses an idea among a group of similar social systems. Innovation is thus considered the condition of being of an organization, the first to produce a new product. (Garzón e Ibarra, 2014).

Implementation of a Quality Program in MSME Attention

Adequate performance (according to the norms) in the interventions considered safe, that are available to the societies in question and that have the capacity to produce an impact on mortality, morbidity, disability and malnutrition. (Forrellat, 2014).

Dedication to the entrepreneur's business

It refers to the proportion of daily time that the business is active; it can be part-time or full-time, morning and afternoon.

Advertising of services through social networks

Online advertising continues to be one of the fastest growing areas of marketing along with video marketing and content management for websites. This is because more and more users are replacing traditional entertainment and information media to choose to find what they need on the Internet. (Chunga, 2019)

Hypothesis

The general hypothesis was: *The source of financing, strategic planning and the use of ICTs by the company, managerial training, innovation, the application of a quality of care program, dedication to the business of the entrepreneur and advertising in social networks they have a significant effect on the success of MSMEs in the health sector of the city of Huancayo.*

Participants

Health establishments (medical offices, medical centers, polyclinics, clinics, medical support services) were selected from the private sector that were registered in the National Registry of Healthcare Providers (RENIPRESS), entity of the National Superintendence of Health, as of January 2020. In the city of Huancayo, 381 establishments are registered.

The establishments found in the three representative districts of the city were identified: Huancayo Cercado, El Tambo and Chilca. As there is not a very wide area, a census will be carried out, that is to say, an investigation with the complete region.

Instrument

A structured survey of business owners was conducted. The survey had a first (descriptive) section, through which the general data of the entrepreneurs and the general information (intervening variables) of the MSMEs were collected under the following detail: general information about the entrepreneurs (age, gender, grade instruction, number of dependents, marital status) and general information about the companies (seniority, classification, size).

The second section of the survey collected information on the independent variables and the dependent variable, which were used to estimate the model. This second

part contained the following variables: MSME financing source, MSME strategic planning, use of ICTs, managerial training of the entrepreneur, innovation, implementation of the MSME Service Quality Program, dedication to the business of the entrepreneur and advertising of services through social networks.

Analysis of data

For the general information sections, related to the intervening variables (descriptive evaluation of the characteristics of entrepreneurs and companies), analysis of the frequencies of the variables will be used, using the Excel software package.

- Age of the employer : frequency distribution
- Gender of the employer : frequency distribution
- Age of the company : frequency distribution
- Marital status : frequency distribution
- Dependent number : frequency distribution
- Annual company income : frequency distribution
- Type of healthcare center : frequency distribution
- Category of the healthcare center : frequency distribution

Whereas, for the analysis of the relationship between the explanatory (independent) and the explained (dependent) variables, with which the econometric model (single-equation, linear, static type) was estimated; a multiple regression analysis was performed using SPSS version 24 software package.

For the evaluation of the model, the Pearson correlation coefficient was used, estimating the relationship between the independent and dependent variables, the coefficient of determination, and the goodness of fit of the regression equation.

To test the General Hypothesis, the ANOVA regression test was used to estimate whether the independent variables jointly contribute information to the explanation of the dependent variable. For the testing of the Specific Hypotheses, the significance tests, t-tests and their critical levels were used.

For the verification of the econometric model, it was shown that it fulfilled the following assumptions:

- Linearity, run partial regression analysis for each of the independent variables. The graph of each partial regression was evaluated.
- Independence, information on the degree of independence between the independent variables. The Durbin-Watson statistic was used.
- Homoscedasticity, the hypothesis of homoscedasticity establishes that the variability of the residuals is independent of the explanatory variables. The plot of predicted values versus squared residuals was examined.
- Normality, the degree to which the standardized residuals approximate a normal distribution. The Kolmogorov-Smirnov Test and graphical tests were used.
- Non-collinearity, they report on how many different dimensions or factors underlie the set of independent variables used. The review of the collinearity diagnosis eigenvalues was used.

Results

General Results

The MSMEs of the health sector of the city of Huancayo in 2020, are directed mostly by young and middle-aged adults, between 31 and 50 years old (63.25%); male (64.83%); married marital status (46.19%) and have a family consisting of three to four members (55.91%). The majority of the companies have been in operation for 6 and 10 years, representing the 53.28%. Most of them correspond to outpatient clinic type health establishments; and the vast majority of them generate income of up to 150 UIT (S/.0 - S/.630,000) reaching 86.61%; income range that corresponds to the microenterprise classification.

The 74.80%, of the MSMEs of the health sector in the city of Huancayo in 2020, accessed financing through a variety of financial instruments (banks and municipal savings and credit banks). Therefore, bank loans are the most important form of financing in this sector. The 68.77% have formulated some type of Business Plan or Strategic Plan. Entrepreneurs, to a greater extent, have taken the initiative to implement strategic management actions in their companies. The 36.48% are using some type of Information and Communication Technology in health facilities.

The 32.02%, the owners of MSMEs of the health sector in the city of Huancayo in 2020, stated that they have some type of management training, be it training in planning, marketing or other business management topics. Most of the MSMEs of the health sector in the city of Huancayo in 2020 (67.19%), stated that they develop a service with a new approach or characteristics different from their competition. Most of the MSMEs of the health sector in the city of Huancayo in 2020 (64.57%), stated that they develop quality plans or programs.

Slightly more than half of the owners of MSMEs in the health sector in the city of Huancayo in 2020 (58.79%), expressed that they dedicate themselves full time to their business. In particular, in the case of doctors, they usually work in two or three institutions simultaneously (one of them, generally in a public institution).

Only a third (33.86%) of the MSMEs in the health sector in the city of Huancayo in 2020 use social networks such as Facebook, WhatsApp, and Twitter to advertise their companies.

Regarding the size of the growth of the company, none of the owners of MSMEs of the Health Sector of the city of Huancayo, believed that the company had a terrible growth. 0.52% (2 cases) believed that the growth experienced was bad.

Meanwhile, 22.83% (87 cases) of those surveyed stated that growth was regular; while 61.15% (233 cases) believed that the growth of the company was good; and 15.49% (59 cases) rated it as very good. Regarding the dimension of the company's profitability, no one thought that the company had a terrible profitability. The 6.04% (23 cases) believed that the profitability experienced was bad.

On the other hand, 26.25% (100 cases) of those surveyed stated that profitability was regular; while 54.86% (209 cases) believed that the profitability of the company was good; and 12.86% (49 cases) rated it as very good. Regarding the productivity dimension of the company, no one thought that the company had a terrible productivity. The 3.94% (15 cases) believed that the productivity experienced was bad.

It was also found that 24.67% (94 cases) of the respondents stated that productivity was regular; while 50.13% (191 cases) believed that the productivity of the company was good; and 21.26% (81 cases) rated it as very good.

By adding the scores of each of the three previous components, the following result was obtained. The 0.52% (2 cases) obtained a final score of 6 points, 3.41% (13 cases) of 7 points, 2.10% (8 cases) of 8 points, 6.82% (26 cases) of 9 points, 16.01% (61 cases) of 10 points, 12.60% (48 cases) of 11 points, 27.30% (104 cases) of 12 points, 18.90% (72 cases) of 13 points, 7.35% (28 cases) of 14 points; and 4.99% (19 cases) reached the maximum score on the rating scale, 15 points. See figure 1.

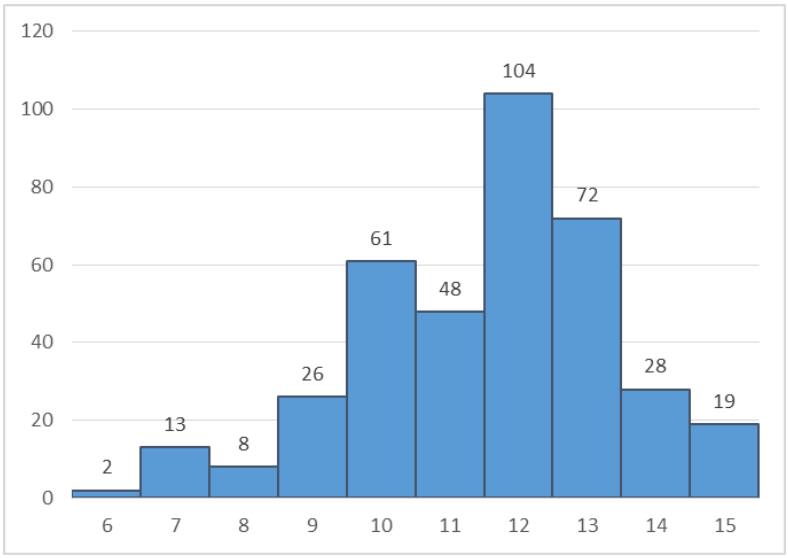


Figure 1. Assessment of the success of companies, MSMEs in the Health Sector, Huancayo, 2020.

Econometric model formulation

Model Development

Using the SPSS V 24 application, the multiple regression analysis was processed, taking the success of MSMEs as a dependent variable and independent of the source of financing, strategic planning, use of ICTs, business training, innovation, quality plan, dedication to business and advertising through social networks. Through this analysis, the following results were obtained.

Then it was proceeded to the analysis of the significance of each of the independent variables. The following hypothesis test was applied for each independent variable (x_j):

H_0: $\beta_j = 0$; H_1: $\beta_j \neq 0$; critical level (sig.) = 0.05

If sig. $\beta_j < 0.05$ then the null hypothesis is rejected (See table 1.)

Table 1
Regression coefficients of the Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020

Model	Non-standardized coefficients		Standardized coefficients	t	Sig.
	B	Standard error	Beta		
(Constante)	9,051	,189		47,925	,000
Finna	,422	,170	,098	2,484	,013
SP	,405	,173	,101	2,339	,020
ICTs	,377	,170	,097	2,212	,028
Traini	,850	,178	,212	4,774	,000
Innov	1,526	,164	,384	9,304	,000
Quali	,024	,160	,006	,149	,882
Dedic	,563	,151	,148	3,722	,000
Netwo	,363	,166	,092	2,192	,029

Note: a. Dependent variable: Ext_Emp

Table 1 shows that the variables source of financing, strategic planning, use of ICTs, business training, innovation, quality plan, dedication to business and advertising through social networks, obtained a significance lower than 0.05. Therefore, the null hypothesis is rejected and the alternative hypothesis is accepted. It is concluded then that these variables are significant for the model.

On the other hand, for the Quality Program variable, the significance value was 0.882. This value, being greater than 0.05, would make the null hypothesis accept. Therefore, this variable is not significant for the model as expected a priori.

In the model, we should consider eliminating the Quality Program variable and performing a new multiple regression analysis with the other seven independent variables that were significant.

The quality plan variable is now excluded. Through this analysis, the following results were obtained, see table 2.

Table 2.
Regression coefficients of the Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020 (corrected version)

Model		Non-standardized coefficients		Standardized coefficients	t	Sig.
		B	Standard error	Beta		
1	(Constant)	9,057	,183		49,387	,000
	Finna	,422	,170	,098	2,488	,013
	SP	,411	,169	,102	2,439	,015
	ICTs	,378	,170	,097	2,222	,027
	Traini	,849	,178	,212	4,778	,000
	Innov	1,532	,158	,385	9,693	,000
	Dedic	,563	,151	,148	3,731	,000
	Netwo	,364	,165	,092	2,201	,028

Note: a. Dependent variable: Ext_Emp

Using the values found, the equation of the estimated regression line is as follows:

$$\mathbf{Y = 9.057 + 0.422\ x_1 + 0.411\ x_2 + 0.378\ x_3 + 0.849\ x_4 + 1.532\ x_5 + 0.563\ x_6 + 0.364\ x_7}$$

From this equation, the following is deduced:

- In the event that the MSME of the Health Sector of the city of Huancayo resorted to a loan granted by a financial institution, the company's success rating score would increase by 0.422 units.
- If it has a Strategic Plan or Business Plan, the company's success rating score would increase by 0.411 units.
- If it has an Information and Communication Technology system for its activities, the company's success rating score would increase by 0.378 units.
- If the employer has a managerial training degree or course, the company's success rating score would increase by 0.849 units.
- If the MSMEs offered new services or a different approach to those of the competition (innovation), the company's success rating score would increase by 1.532 units.
- In the event that the owner of the MSME devotes himself full time to his business, the company's success rating score would increase by 0.563 units.
- In the event that social networks such as Facebook or WhatsApp are used for advertising, the company's success rating score would increase by 0.364 units.

From the evaluation of the standardized coefficients, which establish the relative importance of each of the variables, it could be deduced that the three most important determinants for the model are: innovation (standardized coefficient 0.385), managerial training of the entrepreneur (standardized coefficient 0.212) and dedication to the business (standardized coefficient 0.148).

Goodness of fit

The coefficient of determination, also called R-squared, reflects the goodness of fit of a model to the variable that it intends to explain. In the present model, an R2 of 0.473 was obtained. Therefore, it is established that the qualification of the Success of the MSMEs of the Health Sector of the city of Huancayo in 2020, can be explained by 47.30% by the independent or explanatory variables considered in the model. See table 3.

Table 3
Coefficient of determination of the Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020

Model	R	R-squared	Ajusted R-squared	Standard error of the estimate
1	,688	,473	,463	1,370

Note: a. Predictors: (Constant), Reds, Finan, Dedic, Innov, ICTs, PE, Form

Regression testing

Using SPSS V24, the following results were obtained for the regression model contrast. See table 4.

Table 4
Regression testing (ANOVA), Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020

Model		Sum of squares	gl	Root mean square	F	Sig.
1	Regression	628,757	7	89,822	47,890	,000[b]
	Remainder	699,595	373	1,876		
	Total	1328,352	380			

Note: a. Dependent variable: Ext_Emp
b. Predictors: (Constant), Netwo, Finna, Dedic, Innov, ICTs, SP, Traini

We proceeded to verify that the independent variables contribute information jointly to the explanation of the dependent variable. For this purpose, the following approach is used to contrast hypotheses:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$

H_1: some $\beta_j \neq 0$; critical level (sig.) = 0.05

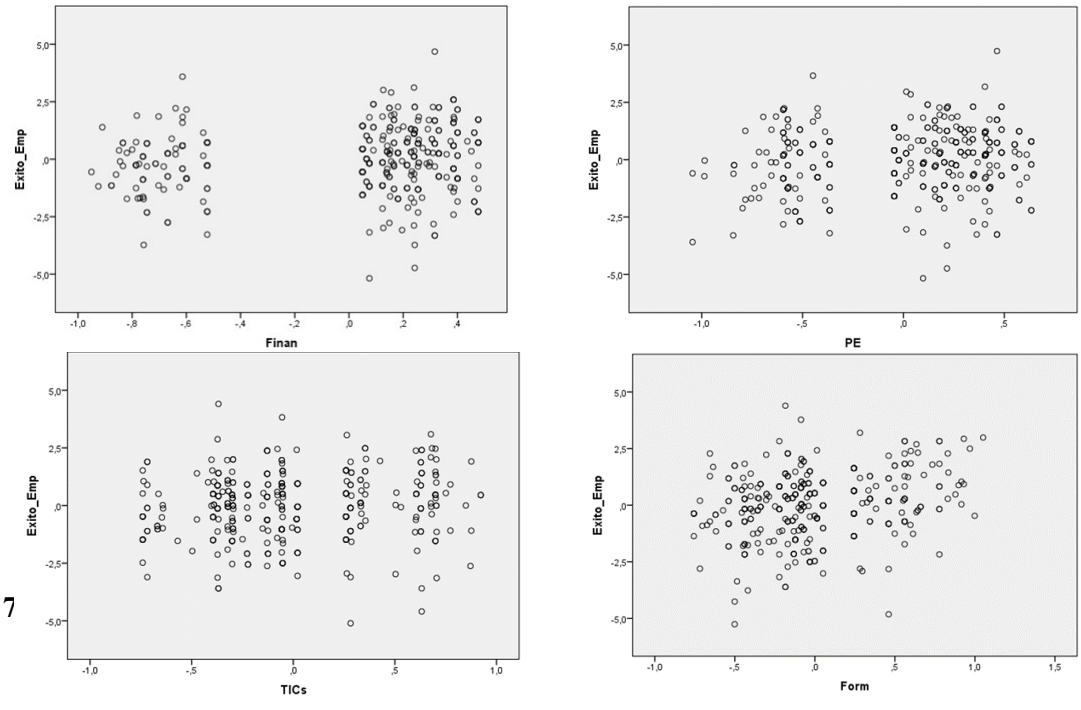
If sig. F < 0.05 then the null hypothesis is rejected

As observed in table 4, the sig. of the F obtained is 0.000. Therefore, the null hypothesis is rejected, the alternative hypothesis is accepted. It is concluded that all the independent variables (source of financing, strategic planning, use of ICTs, business training, innovation, dedication to the business and advertising through social networks) jointly and linearly influence the MSMEs Success rating of the Health Sector of the city of Huancayo in 2020.

Model check

Assumption of Linearity

Partial regression diagrams give you a quick idea of the form a relationship takes. They allow us to examine the relationship between the dependent variable and each of the independent variables separately, after eliminating from them the effect of the rest of the independent variables (Pardo and Ruiz, 2015). See figure 2.



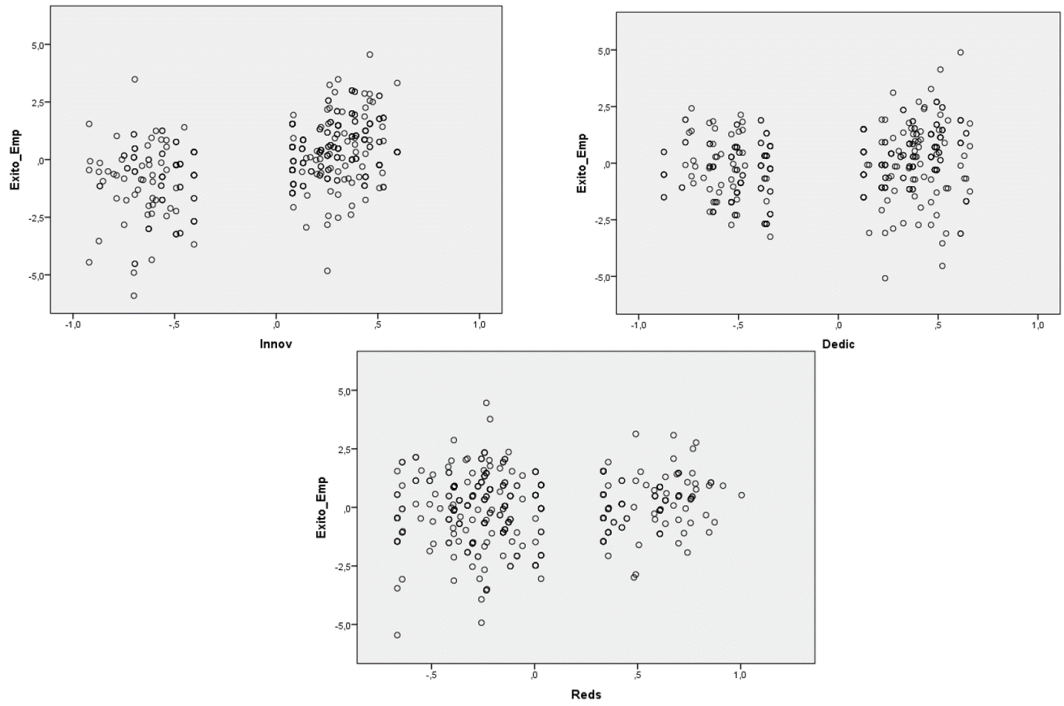


Figure 2. Partial regression, Success of the companies and independent variables. Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020.
Source: Survey. Processed by SPSS V.24

According to Velarde (2010), taking into account the graphic representation when X adopts two unique values, it is observed as two vertically aligned series of points that represent the variability of Y for each of the values of X, it can be said that the line constitutes a good representation to join both series, representing the change suffered in the estimated Y as a function of the change (from 0 to 1 - from one category to another-) in X. When observing the partial regression graphs of financing source, management training, formalization and dedication to the business precisely the behavior of two series aligned vertically is observed. On the other hand, in the case of entrepreneurship and business spirit, a linear trend of positive slope is observed. Therefore, the linearity assumption holds.

Assumption of Independence

The Durbin-Watson statistic provides information on the degree of independence between them. The DW statistic oscillates between 0 and 4, and takes the value 2 when the residuals are independent. We can assume independence when it takes values between 1.5 and 2.5 (Pardo and Ruiz, 2015). A value of 1,676 was obtained for the Durbin Watson statistic, it can be established that the proposed Econometric Model complies with the independence assumption. See table 5.

Table 5

Durbin Watson Statistic, Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020.

Model	R	R-squared	Adjusted R-squared	Standard error of the estimate	Durbin-Watson
1	,688[a]	,473	,463	1,370	1,676

Note: a. Predictors: (Constant), Netwo, Finna, Dedic, Innov, ICTs, SP, Traini

b. Dependent variable: Exito_Emp

Source: Survey. Processed by SPSS V.24.

Assumption of Homoscedasticity

The Linear Regression procedure in SPSS has a series of graphs that allow obtaining information on the degree of compliance with homoscedasticity assumptions. The homoscedasticity hypothesis establishes that the variability of the residuals is independent of the explanatory variables (Pardo and Ruiz, 2015). In Figure 3, generated by SPSS, it is observed that no association is found between the variation of the residuals and the values of the forecasts. Therefore, the assumption of homoscedasticity is fulfilled.

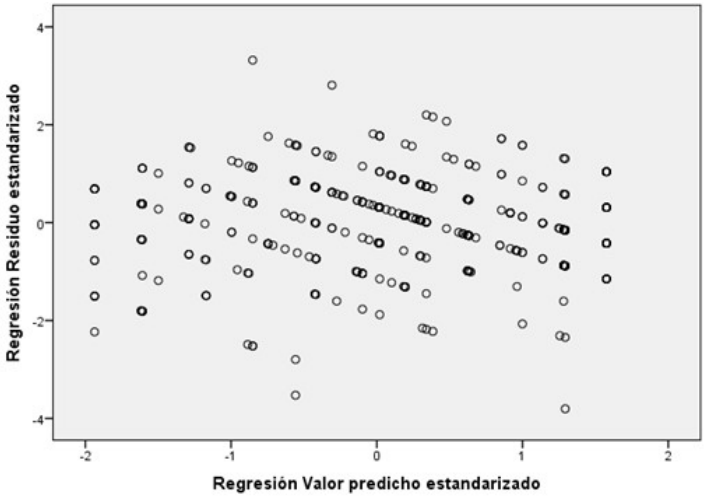


Figure 3. Scatter plot of typified forecasts by typified residuals. Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020.

Assumption of Normality

For this analysis, the Kolmogorov-Smirnov test was used for the standardized residues of dependent variable; which raises the following hypotheses:

H_0: remainders of group i are normal

H_1: remainders of group i are not normal

If the p-value > 0.05 we cannot reject the null hypothesis and therefore we assume that the assumption of Normality is fulfilled. The sig. obtained was 0.003 (less than 0.05); therefore, the null hypothesis is rejected and the normality assumption for the model would not be fulfilled. In this situation, where the simple Kolmogorov-Smirnov test is contradictory, it is advisable to carry out the graphical test, where we can "graphically" observe whether the data of our variable are normally distributed or not (Romero-Saldaña, 2016). Using SPSS, a histogram of the typified residuals was generated with a

superimposed normal curve (see figure 4). In this graph, there is an accumulation of cases in the central part of the curve and a slight asymmetry towards the left tail. The distribution of the residuals, thus, the model fits the normal probability curve.

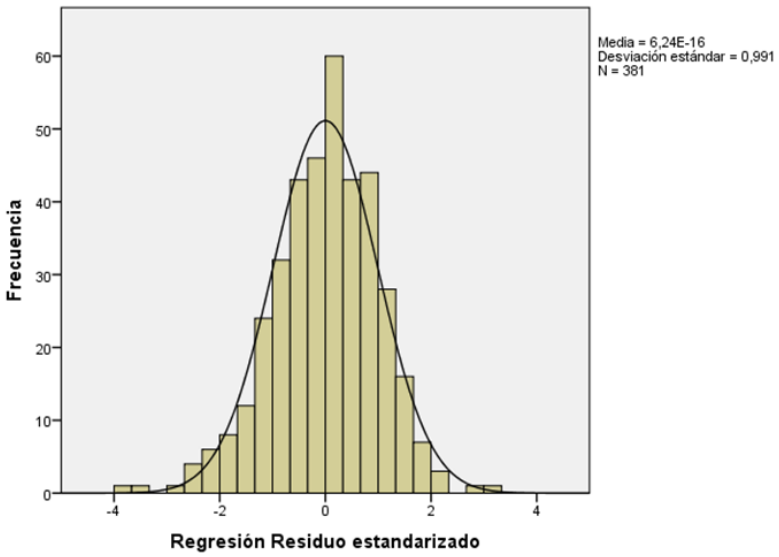


Figure 4. Standardized residual histogram. Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020.
Source: Survey. Processed by SPSS V.24.

Assumption of Non-Collinearity

The diagnosis was made to determine the non-collinearity between the independent variables of the model. In this assessment, the eigenvalues are evaluated, which inform about how many different dimensions or factors underlie the set of independent variables used. The presence of several eigenvalues close to zero indicates that the independent variables are closely related to each other (collinearity). In conditions of non-collinearity, these indices should not exceed the value 15. Values greater than 30 indicate the presence of collinearity (Pardo and Ruiz, 2015).

It is observed that all the eigenvalues are different from zero and that the condition indexes are less than 15. Thus, the econometric model complies with the assumption of non-collinearity. See table 6.

Table 6
Collinearity diagnosis. Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020

Dimension	Eigenvalue	Condition index	Variance proportions							
			(Constant)	Finna	SP	ICTs	Traini	Innov	Dedic	Netwo
1	5,550	1,000	,00	,01	,01	,01	,01	,01	,01	,01
2	,669	2,881	,02	,02	,00	,14	,29	,04	,02	,08
3	,515	3,283	,00	,01	,01	,25	,00	,01	,00	,70
4	,368	3,883	,00	,00	,06	,28	,46	,00	,24	,15
5	,327	4,119	,01	,08	,02	,17	,22	,01	,61	,02
6	,256	4,660	,00	,07	,12	,07	,00	,80	,06	,01
7	,208	5,170	,00	,44	,65	,06	,01	,02	,00	,03
8	,108	7,164	,96	,37	,12	,01	,01	,11	,07	,01

Note: a. Dependent variable: Exito_Emp

It is concluded that the proposed econometric model meets the five linear regression assumptions. Therefore, it is considered valid.

Hypothesis testing

Being the econometric model for this hypothesis:

$$\mathbf{Y = 9.057 + 0.422\ x_1 + 0.411\ x_2 + 0.378\ x_3 + 0.849\ x_4 + 1.532\ x_5 + 0.563\ x_6 + 0.364\ x_7}$$

Note: the quality program variable is excluded in this contrast, as it was not significant.

For a linear regression, it is taken into account that Hypothesis testing:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$

H_1: some $\beta_j \neq 0$

Critical level (sig.) = 0.05

If sig. F < 0.05 then the null hypothesis is rejected

Then for the model:

H_0: $Y \neq 9.057 + 0.422\ x_1 + 0.411\ x_2 + 0.378\ x_3 + 0.849\ x_4 + 1.532\ x_5 + 0.563\ x_6 + 0.364\ x_7$

H_1: $Y = 9.057 + 0.422\ x_1 + 0.411\ x_2 + 0.378\ x_3 + 0.849\ x_4 + 1.532\ x_5 + 0.563\ x_6 + 0.364\ x_7$

Like the sig. of the F obtained is 0.000, therefore, the null hypothesis is rejected and the alternative hypothesis is accepted. In addition, the R2 found was 0.463, a value that would indicate an acceptable explanation of the dependent variable by the considered independent variables.

Therefore, the validity of the general hypothesis proposed for the present thesis is verified (the original econometric model having been corrected after the exclusion of the variable "quality program").

The corrected version of the general hypothesis would be: *"The source of financing, strategic planning and the use of ICTs by the company, management training, innovation, dedication to the business of the entrepreneur and advertising on social networks have a significant effect on the success of MSMEs in the health sector of the city of Huancayo."*

Discussion

The econometric model of the Econometric Model of the Success of MSMEs in the Health Sector, Huancayo, 2020; it met the assumptions of linearity, independence, homoscedasticity, normality and non-collinearity, therefore, it is considered valid. However, the model was corrected, because on the first occasion that the analysis was carried out using the SPSS application, the independent variable of "Quality plan or program" was rejected as it was not statistically significant. Only the other seven variables were maintained: the source of financing, strategic planning, the use of ICTs by the company, management training, innovation, dedication to the business of the entrepreneur and advertising on social networks.

Regarding the test for goodness of fit for this model, an adjusted R^2 of 0.463 was reached, which means that the seven factors considered in the econometric model (the source of financing, strategic planning, the use of ICTs by the company, management training, innovation, dedication to the business of the entrepreneur and advertising on social networks) explain 46.3% of the success of MSMEs in the health sector of the city of Huancayo, Peru. Therefore, this model can be considered as regular, because according to the theory, an R^2 that is between 0.5 and 0.85 is classified as good. There is still 53.7% of the phenomenon that are not explained by these variables. Therefore, this proposed model should be considered as exploratory and in future research, expand a greater number of explanatory variables to consider.

In this econometric model, the success of MSMEs in the health sector of the city of Huancayo was considered as a dependent variable, which in turn was made up of three dimensions: growth, profitability and productivity. For each of them, the response was assessed using the 5-point Likert Scale (1 = total disagreement and 5 = total agreement), which, adapted for the present research work, was established with the following format: 1 = Terrible, 2 = Bad, 3 = OK, 4 = Good and 5 = Very Good. The sum of the qualification of each one of the dimensions made the score of the qualification of the success of the MSMEs. The rating was granted by the entrepreneurs themselves. This instrument was based on a similar one used by Vílchez (2017) and Rocca (2017), who also used a rating system like the one developed in the present research work; although, in these two cases cited, the instrument was used for companies in general and not for a sector as specific as health.

Conclusion

- The proposed general hypothesis was verified, which establishes that, the source of financing, strategic planning and the use of ICTs, management training, innovation, application of a quality program, dedication to business and advertising on social networks; they intervene in the success of MSMEs in the health sector of the city of Huancayo.
- Of these variables, the source of financing, strategic planning, use of ICTs, management training, innovation, dedication to the business and advertising on social networks, turned out to be statistically significant, therefore, better related to the success of MSMEs in the sector health in Huancayo.
- On the other hand, the application of a quality program, as it is not statistically significant, would not be related to the success of the company as expected.

- Therefore, the econometric model had to be corrected, excluding the non-significant independent variable. Thus, the corrected hypothesis was the following: the source of financing, strategic planning and the use of ICTs, management training, innovation, dedication to business and advertising on social networks; they have a significant effect on the success of MSMEs in the health sector of the city of Huancayo.
- The econometric model met the assumptions of multiple linear regression. This model, therefore, it can be considered as valid.

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RELEVANT ASPECTS OF THE DEVELOPMENT PROJECTS IN INDIGENOUS ORGANIZATIONS OF CAUCA

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Abstract. This article is the product of an investigation that aimed to identify the most relevant aspects of development projects in the indigenous context, mainly from the perspective of indigenous social organizations and their experts. It was based on the question: What is the situation and requirements in the formulation of projects in the current conditions of development of the indigenous population of Cauca? The research was carried out under a mixed non-experimental correlational cross-sectional approach, for the quantitative part a survey was conducted aimed at project formulators and for the qualitative part a semi-structured interview directed to experts was applied, the data was analyzed through the SPSS software and Atlas ti. respectively. As results, it was found that there is good knowledge at the conceptual level by the formulators, but that it is not enough to have the level of expertise required to formulate and evaluate public investment projects in the indigenous indigenous context, however, this situation has not It has been an impediment to the development of projects, since experts were sought to fill that conceptual and expertise gap. The use of methodologies of the National Planning Department (NPD) in Colombia is concerned, for example, a problem was found with the use of the General Adjusted Methodology (MGA), being a condition for the approval of public projects in Colombia.

Keywords: Planning, development planning, public investment projects and project theory.

ASPECTOS RELEVANTES DE LOS PROYECTOS DE DESARROLLO EN ORGANIZACIONES INDÍGENAS DEL CAUCA

Resumen. El presente artículo es producto de una investigación que tuvo como propósito la identificación de los aspectos más relevantes de los proyectos de desarrollo en el contexto indígena caucano, principalmente desde la visión de las organizaciones sociales indígenas y sus expertos. Se partió de la pregunta ¿Cuál es la situación y exigencias en la formulación de proyectos en las actuales condiciones de desarrollo de la población indígena caucana? La investigación se desarrolló bajo un enfoque mixto no experimental de tipo transversal correlacional, para la parte cuantitativa se aplicó una encuesta dirigida a

formuladores de proyecto y para la parte cualitativa se aplicó una entrevista semiestructurada dirigida a expertos, los datos fueron analizados a través del software SPSS y Atlas ti respectivamente. Como resultados están la existencia de buenos conocimientos a nivel conceptual por parte de los formuladores, pero no es suficiente para tener el nivel de experticia requerido para formular y evaluar proyectos de inversión pública en el contexto indígena caucano, sin embargo, esta situación no ha sido un impedimento para el desarrollo de proyectos, puesto que se ha buscado a expertos que llenen ese vacío conceptual y de experticia. Preocupa el uso de metodologías propias del Departamento Nacional de Planeación (DNP) en Colombia, por ejemplo, se encontró un problema con el uso de la Metodología General Ajustada (MGA), siendo una condición para la aprobación de proyectos públicos en Colombia.

Palabras clave: Planeación, planeación del desarrollo, proyectos de inversión pública, teoría de proyectos.

Introduction

In Colombia, planning in the public context is defined by the National Planning Department (NPD), an entity that specifies methodologies and technical guidelines for the construction of plans, programs and projects for the entire Colombian territory (National Planning Department Normogram, 2017), thus to access public resources it is necessary to know all the tools made available by this body. Indigenous social organizations have to adapt to the NPD methodologies to access State resources, therefore, they must articulate the problems of their context with these tools and thus promote the development of their communities.

According to the 2018 National Census, the department of Cauca is made up of 1,404,205 inhabitants, of which 351,419 inhabitants belong to indigenous communities organized in 105 reservations, 70% belonging to the Nasa people, 9.4% to the Yanacona people , 6.4% to the Misak people and 5.8% to the Coconuco people, the remaining 8.4% are part of the towns of Totoró, Eperara Siapodara and other towns. The GINI index in 2018 for Cauca was 0.52 and people living in poverty was 50.5% and extreme poverty was 22.9%. When comparing these indicators with the most representative populated centers in the country, a GINI index of 0.446 is found, people in poverty of 36% and in extreme poverty of 15.4% (DANE, 2019); therefore, there is evidence of a gap between the department's indicators with the mean of the population of considerable populated centers. The proportion of people with Unsatisfied Basic Needs was 18.27% and 3.15% in poverty. (DANE, 2018). Geographically, Cauca is located in the southwestern part of Colombia, has an area of 30,169 km^2 and is divided into 42 municipalities (Government of Cauca, 2012).

Since the mid-twentieth century, the Colombian state has been implementing planning methods adapted from the experiences of other countries in its processes, through entities such as the NPD, these processes began being centralized and in recent decades they have sought to be participatory, in such a way that the population takes part in the construction of their own plans and participates in their own development. For indigenous organizations in the department of Cauca it is of great relevance to assume this responsibility to envision and build their own development, for this reason the question arises what is the situation and requirements in the formulation and evaluation of projects in current development conditions of the Cauca indigenous population? To answer the question, it was assumed that there is a sufficient degree of technical - conceptual knowledge on the part of the project formulators, but the knowledge of the environment and the expertise is not yet sufficient to achieve optimal results in the projects, also on how the identification of relationships between the vision of indigenous

organizations and the vision of the State are fundamental for obtaining more efficient results from development projects.

Among the different theoretical elements that based the research are the new instruments for world development that are proposed after the financial crisis of 2008, where failures are identified at the level of economic policy formulation and that have had a negative impact on employment, prices and quality of life; therefore, the new methodologies must be aligned under the concept of sustainability and the balance of material wealth, seeking the protection of the environment, equity and social justice. As a result, new development paradigms have been generated, some of which are contained in the Millennium Development Goals and, today, in the Sustainable Development Goals (United Nations, 2010).

The new paradigms will influence planning methods, but this situation will be relevant if States take responsibility for the different processes as part of the functions of the relevant State entities and at their different hierarchical levels. In this regard (Escudero, 2014) considers that planning as an activity and process must directly influence the object of intervention based on conditions that will be clarified in the future.

In Colombia, the National Planning Department presents some guides that contain the methodologies and tools to carry out planning exercises and public investment projects, among them are theoretical elements of projects which are made up of the components of identification, preparation, evaluation and programming. For example, the (Department of Investments and Public Finance, 2015) presents the conceptual manual of the General Adjusted Methodology (MGA) where each of the items that are part of the identification, preparation, evaluation and programming modules are explained.

Regarding the identification component, its main purpose is to identify problems of the context to intervene; this exercise is carried out using the logical framework approach, which allows the analysis of the problem, the identification of objectives and the alternative solutions among others. The preparation component from the choice of the best alternative solution requires studies of needs, risks, income and/or benefits and economic evaluation; the results will be decisive elements in the execution and management of the project. The evaluation component focuses on the economic analysis of the alternative solution and on the programming component, the different indicators, assumptions and conditions are designed as follow-up tools to fulfill the proposed objectives (National Planning Department, 2016). All results must be documented and are required by the NPD in a software called General Adjusted Methodology (MGA), which is an online platform to upload the project summary with its respective annexes.

For the (General Department of Public Investment --DGIP, 2015), the MGA is so named because the methodology proposes an ordered sequence through some forms; general because it records the most relevant aspects of the project and adjusted because it must be improving as time goes by. This platform is regulated by Resolution 0806 of 2005, which stipulates that any entity of the national, departmental, local and district order must require it for the presentation of projects.

The indigenous population in Latin America in recent decades has achieved the attainment of rights, but it is still not enough, therefore, the challenges to be faced continue to be of great magnitude. The region has had economic and social development, but it has not been representative of the entire population. Furthermore, this growth has not been sustainable nor has it achieved the expected expansion; limiting a large part of these benefits to indigenous people, also because these communities have tended to resist the vision of general development and have fought for diversity, self-determination and

inequality. Having a fundamental role of struggle and resistance on the part of Latin American indigenous social organizations in social movements and acquisition of rights, such as the recognition of diversity, self-determination, human dignity among others, which are stipulated in the declaration of the United Nations on the Rights of Indigenous Peoples in 2007 and the Indigenous and Tribal Peoples Convention of the International Labor Organization (ILO) in 1989, as well as the constitutional reforms (Economic Commission for Latin America (ECLAC), 2014).

In this same sense, the Colombian Constitution recognizes indigenous territories as political and administrative territorial entities, in addition to a certain independence and where indigenous authorities have an autonomous government. Likewise and according to (Bolaños et al., 2012) in the department of Cauca, the indigenous organization of greatest importance is the Regional Indigenous Council of Cauca (CRIC), created from a movement of struggle that strengthened the defense of the territory, recovered the cultural traits and struggle for autonomy.

The development of the research allowed to reach results such as: the formulators have conceptual knowledge about theoretical elements of projects but they are not enough at the moment of making a practical application of them; knowledge of the environment is essential and participatory methodologies are being applied according to the guidelines of the National Planning Department by indigenous organizations. However, there are risks with certain desk formulators who, without knowing the environment, formulate projects; finally, it was found that the degree of use of the General Adjusted Methodology (MGA) is not adequate, but it is an unconditional requirement for the approval of public investment projects in Colombia.

Methodology

The results of the research are the product of a mixed approach, where qualitative and quantitative elements were contemplated, the purpose was the search for greater objectivity, understanding the causal relationships in a given environment. The combination of these two elements is important, according to (Ñaupas, Mejía, Novoa and Villagómez, 2014) the reduction of investigations to a single element is not conducive, since it limits the total quality, and it is important that the procedures complement each other.

The research design was non-experimental of a cross-correlational type; non-experimental because the variables were not manipulated and cross-correlational because causal relationships were sought between the variables at a given time. The variables that were studied were the degree of technical knowledge and the environment on the part of the project formulators and the difficulties presented in the process of formulating public investment projects. It was sought to identify the incidence of technical and environmental knowledge in difficulties when carrying out projects.

The research began with the identification of the indigenous organizations that group the indigenous ethnic groups in the department of Cauca, as well as the identification of the features of their vision of development, in parallel, the theoretical elements that support the methodologies proposed by the National Planning Department (NPD), to later find out what is the degree of knowledge of the methodologies and the

environment by the formulators of projects in the indigenous context and their difficulties when carrying out this type of exercises.

The quantitative exercise was based on a simple random sampling, (Hernandez, Fernández and Baptista, 2014) states that this type of sampling allows the possibility that any member of the population under study has the same chances of being chosen in the sample obtained, through a random selection of units of analysis. The total population was made up of 720 formulators, with a margin of error of 4.3% and a confidence level of 95%, in total we worked with a sample of 302 people.

For the qualitative part, a non-probabilistic sampling of an intentional type was used, since there are few indigenous but very relevant organizations such as the Regional Indigenous Council of Cauca, which groups a significant number of indigenous people from Cauca, also experts who, due to their functions, know about public investment projects in the department; for (Hernandez and others, 2014) the advantage of this type of sampling is that it does not require representativeness but rather a careful and controlled selection of participants with characteristics related to the problem statement. The intentional nature of this type of sampling is due to the fact that essential subjects were chosen for the research because of their training and experience in formulating projects in the indigenous environment.

The research instruments were the survey and the semi-structured interview; the survey questionnaire was created from 22 questions elaborated on the Likert scale and the questions of the interview questionnaire were ten, established from the variables, for both questionnaires the respective pilot test was carried out and presented to the judgment of experts to validate the instruments.

The data analysis for the survey was the SPSS version 20.0 computer tool, taking the descriptive statistics as a reference and the Atlas ti V 5.0 computer tool was used for the data collected from the interview.

Results

Degree of knowledge about the formulation and evaluation of projects in the indigenous context of Cauca

Product of the survey carried out and in relation to the degree of knowledge about the basic planning chain in Colombia by the project formulators on concepts such as planning, plans, programs and projects, the following was found:

In figure 1, regarding the level of knowledge on planning, it can be observed that formulators consider their level of knowledge good with a rating of 4 in 50.3%, excellent with a rating of 5 only 6%, 39.1% fair with a score of 3 and 4.6% deficient with a score equal to or less than two. It is important to evaluate this concept because in the planning hierarchy in Colombia, having a clear planning and its different methodologies will allow the good design of plans, programs and projects.

Scale 1 to 5	Frequency	Percentage	Accumulated percentage
1	4	1,3 %	1,3 %
2	10	3,3 %	4,6 %
3	118	39,1 %	43,7 5
4	152	50,3 %	94 %
5	18	6 %	100 %
Total	302	100 %	

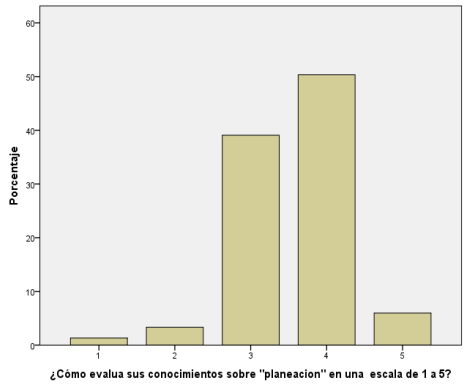

Figure 1. Level of knowledge about "planning."

Note: Source. Own authorship, 2019

Figures 2, 3 and 4 show common elements in terms of the level of knowledge about plans, programs and projects. For example, up to 6% of the formulators have a very high level of knowledge, 40% to 51% of the respondents have a high level of knowledge, 39% to 49% of those who know something, and 4% or less of those with low and very low levels of knowledge. Based on these data, it can be said that, although the entire population of formulators is not in a position to be experts regarding their knowledge, if a good part of the population, more than 80% have knowledge on this subject. The above could be seen as something positive, only that a more integral look should be taken, since it is not only technical knowledge, but also of the environment; moreover, how the knowledge and experience acquired is applied.

	Frequency	Percentage	Accumulated percentage
Know something	147	48,7 %	48,7 %
High	123	40,7 %	89,4 %
Low	12	4 %	93,4 %
Very High	15	5 %	98,3 %
Very Low	5	1,7 %	100 %
Total	302	100 %	

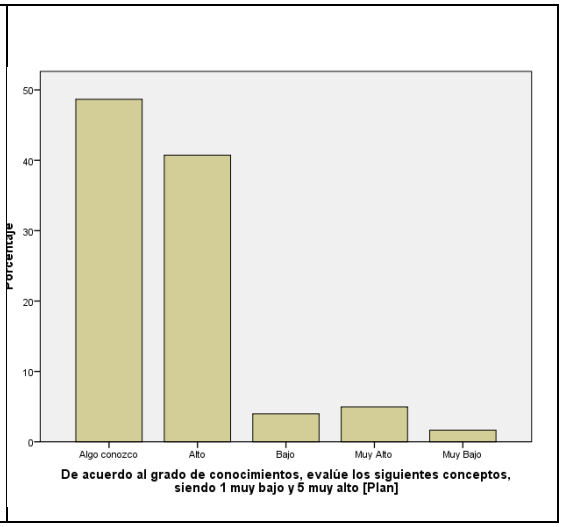

Figure 2. Degree of knowledge about "Plan."

Note: Source. Own authorship, 2019

	Frequency	Percentage	Accumulated percentage
Know something	137	45,4 %	45,4 %
High	134	44,4 %	89,7 %
Low	11	3,6 %	93,4 %
Very High	16	5,3 %	98,7 %
Very Low	4	1,3 %	100 %
Total	302	100 %	

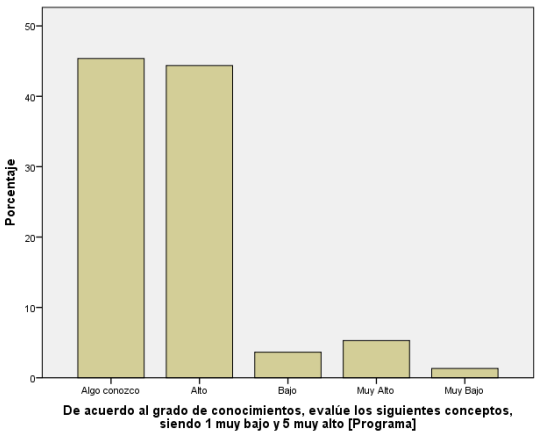

Figure 3. Degree of knowledge about "Program."

Note: Source. Own authorship, 2019

	Frequency	Percentage	Accumulated percentage
Know something	149	49,3 %	49,3 %
High	128	42,4 %	91,7 %
Low	9	3 %	94,7 %
Very High	14	4,6 %	99,3 %
Very Low	2	0,7 %	100 %
Total	302	100 %	

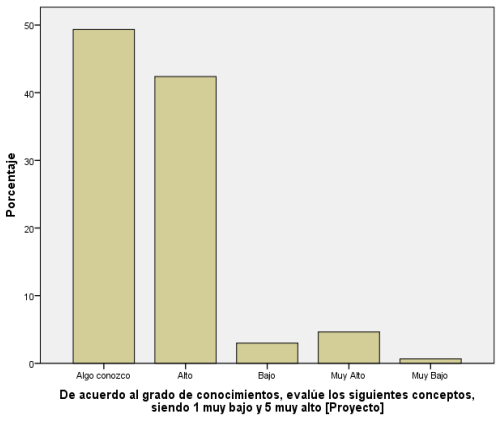

Figure 4. Degree of knowledge about "Projects."

Note: Source. Own authorship

Among the most relevant categories product of the analysis of the interviews and that support or contrast the qualitative studies are: “the degree of knowledge is considered good and/or acceptable,” ratifying the results of the surveys; this is due to the fact that every time experience has been gained in the formulation and evaluation of projects, it is also in a context where there are universities that are influencing at the postgraduate level in training regarding the formulation and management of social projects in the public sector. However, and as part of the results of the interviews, it is highlighted that the evaluation and approval of projects ends up having more influence on political aspects than technical ones, so it may happen that a poorly formulated project ends up being approved because politically there was incidence.

Another category that arises from the interviews is the "degree of knowledge of the environment is not always adequate," this category refers to the degree of understanding of the site to intervene through a project, taking into account the different

problems from social, cultural, economic among others. If the territory is not known, inappropriate alternative solutions can be proposed to solve problems; for which the experts stated that it usually happens that some of the formulators called by them "of desk" do the exercise of preparing a project without knowing the population under study and the territory in which they live, even taking a sample of another project and make changes to the wording, this must be unacceptable because the results to be obtained will be totally out of focus, thus wasting time, effort and resources.

With the aforementioned, it is essential to have comprehensive project formulators, who have theoretical knowledge, but also knowledge of the environment to intervene; or at least that possible participatory strategies are proposed so that together with the community they can carry out the exercise of identification of problems and/or needs and at the same time analyze possible alternative solutions. There must also be a formulator who has had not only academic but also professional training processes, where he has gained experience in putting his knowledge into practice and really, with the conjunction of these elements, acquires the condition of expert; without forgetting that in the world of projects each new exercise must be considered a new challenge, in addition that knowledge must be constantly updated and more so in the public sector when adjustments are made to methodologies constantly.

	Frequency	%	Accumulated percentage
Sometimes	186	61,6%	61,6 %
Definitely no	8	2,6%	64,2 %
Definitely yes	75	24,8%	89,1 %
I have not formulated projects	33	10,9%	100 %
Total	302	100 %	

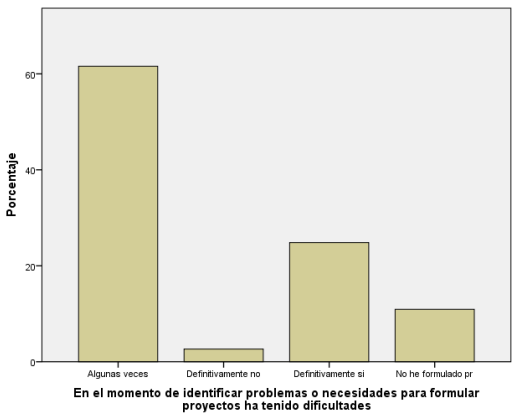

Figure 5. Difficulties in identifying problems or needs.

Note: Source. Own authorship, 2019

Figure 5 has a relevant aspect at the level of public investment projects in the Cauca indigenous context; this is because having a clear problem is one of the most important success factors at the level of project formulation, evaluation and management. In addition, this category is directly related to the degree of knowledge of the environment. It is interesting and at the same time worrying to identify that 24.8% of the formulators have had difficulties at this stage and that 61.6% of them have had difficulties at times, which becomes a high percentage of formulators with problems when identifying problems and/or needs and should call attention to a prompt solution to reduce these percentages to reduce the risk of inefficient project results in the Cauca indigenous context.

Another category that emerges from the interviews is the "analysis of the environment in a participatory manner." In the indigenous context, mainly in the Regional Indigenous Council of Cauca (CRIC), presenting a project implies meeting several times with the different actors that have a relationship with the project, through an exercise that is called "the mingas of thought" and where the profiles of the projects are constructed, prevailing the previous community work and agreeing on the decisions. The Universidad Indígena also participates in this process by forming three councils (political, pedagogical, and administrative). On the other hand, care must be taken with those so-called of "desk" formulators who, without knowing the context, pose problems and/or needs with the risk that they will be misunderstood, in addition to only concentrating on obtaining resources that are not really required.

The National Planning Department (NPD) promotes the development of participatory work in planning exercises, and indigenous organizations have not been immune to these calls. In addition, community participation is a very characteristic of indigenous communities in the department of Cauca and in Colombia in general.

At the level of technical studies (figure 6), the fact that 19.5% of the formulators state that they do not know about technical studies and that 28.5% have always had difficulties in carrying them out is a very worrying situation; this indicates that a large percentage of the projects are built with unreliable technical studies or that there is a need to go to the experts, who according to the survey are few, being represented by only 6.3%.

	Frequency	%	Accumulated percentage
I had some difficulties	138	45,7%	45,7 %
I have not had any difficulties	19	6,3%	52 %
I don't know it	59	19,5%	71,5 %
I have always had difficulties	86	28,5%	100 %
Total	302	100%	

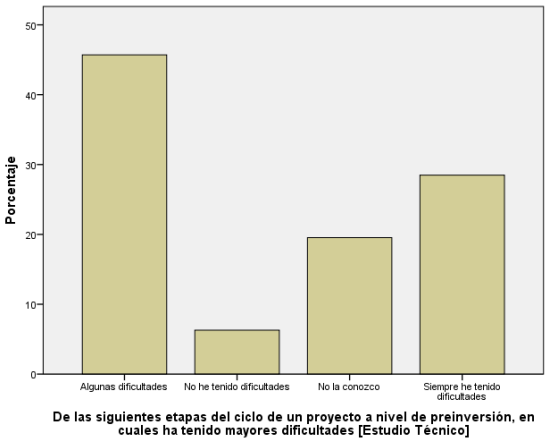

Figure 6. Difficulties at the Technical Studies level.

Note: Source. Own authorship, 2019

	Frequency	%	Accumulated percentage
I had some difficulties	129	42,7%	42,7 %
I have not had any difficulties	18	6%	48,7 %
I don't know it	68	22,5%	71,2 %
I have always had difficulties	87	28,8%	100 %
Total	302	100%	

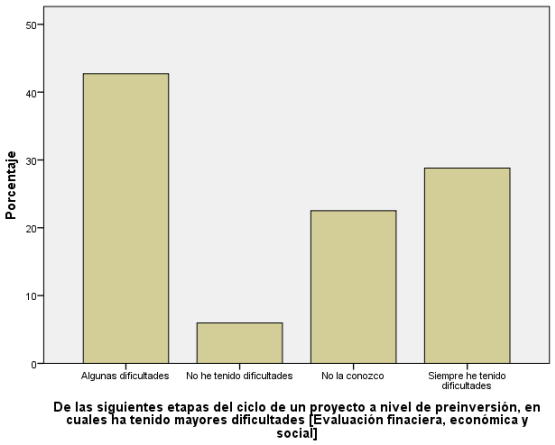

Figure 7. Difficulties at the level of financial, economic and social evaluations.

Note: Source. Own authorship, 2019

Figures 6 and 7 referring to difficulties at the level of technical studies and financial, economic and social evaluations, denote equally worrying situations; for example, it is not conceivable that a percentage of formulators who are between 19% and 23% state that they do not know this type of studies; furthermore, that 28.5% of them state that they have always had difficulties, and that between 42% and 46% have had some difficulties. These are worrying figures for the formulation, evaluation and management of projects in the indigenous context of Cauca.

In general terms, the previous results show a contradiction between the knowledge at the level of plans, programs and projects with the different studies in the investment stage of public investment projects. On the one hand there are figures that show that there are good levels of knowledge, but at the time of doing the previous studies, they are not enough to be able to reduce the degree of difficulty that each one of them implies; turning this situation into a considerable risk for the resources that are invested at the level of public investment projects and obtaining efficient results.

Indigenous organizations have at some point lacked people with the appropriate knowledge to carry out technical, financial and economic studies, among others, but according to interviews, this situation has not been an obstacle for the formulation, evaluation and management of projects since experts have been used to solve this type of situation, recognizing by the evaluators precisely the quality of some of the projects presented by the CRIC, but it must be recognized that in this environment there are people who claim to be experts in the elaboration of projects without actually being one.

	Frequency	%	Accumulated percentage
Doesn't know, doesn't answer	3	1%	1%

I have used it, but with many difficulties	64	21,2%	22,2 %
I have used it without inconvenience	51	16,9%	39,1 %
I have not used it	183	60,6%	99,7 %
I'm an expert in the handling	1	0,3%	100 %
Total	302	100%	

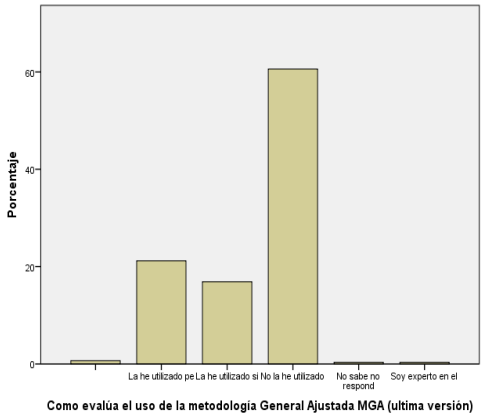

Figure 8. Use of the General Adjusted Methodology MGA (latest version)

Note: Source. Own authorship, 2019

Figure 8 referring to the use of the General Adjusted Methodology (MGA) indicates that of the formulators surveyed, 60.6% of them have not used the web platform, 21.2% have used it with great difficulty and only 16, 9% have used it without difficulty. These figures are also of concern, since the MGA is mandatory for the presentation of any public investment project in Colombia and requires a summary of each of the previous studies of the pre-investment phase.

Although in the department of Cauca there are more and more people with knowledge in project methodologies of the National Planning Department (NPD), there is still a knowledge gap that is evidenced in the results of the survey on the use of MGA, such as a planning official of the Cauca governorate states when he says that in the review several of the sections of the MGA have various inconsistencies from the identification phase to the programming phase. For example, projects based on problem situations that are not real or incoherent to the context where the project will be elaborated, objectives and goals that are unreal, projects with a too short evaluation horizon, among others.

Formulator's level of expertise

One of the elements of the research was to analyze the relationship of knowledge in projects with the level of expertise of the formulators for both the social and productive sectors, this need emerged due to the fact that the technical knowledge and the environment linked to a validated experience will give greater probabilities of success in the formulation, evaluation and management stages of the projects; the following results were found:

	Frequency	%	Accumulated percentage
I have some experience	155	51,3%	51,3 %
I do not have experience	98	32,5%	83,8 %

I am an expert	2	0,7%	84,4 %
I have experience	47	15,6%	100 %
Total	302	100%	

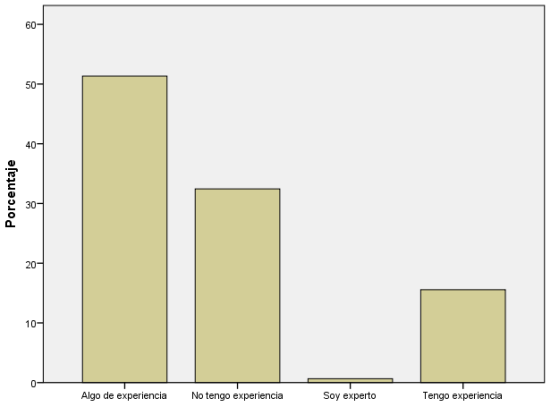

Figure 9. Experience at the level of Social Projects

Note: Source. Own authorship, 2019

According to figure 9, the formulators considered experts are minimal represented with only 0.7%, while those with experience represent 15.6% and with some experience 51.3%. In addition, a high percentage of formulators who have no experience at the level of social projects is seen with 32.5%.

	Frequency	%	Accumulated percentage
I have some experience	135	44,7%	44,7 %
I do not have experience	103	34,1%	78,8 %
I am an expert	2	0,7%	79,5 5
I have experience	62	20,5%	100 %
Total	302	100%	

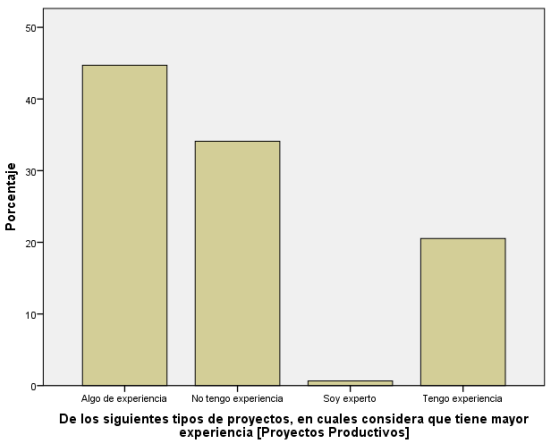

Figure 10. Experience at the level of Productive Projects.

Note: Source. Own authorship, 2019

Regarding productive projects, the figures are higher, but neither with the expected relevance. In figure 10, it is evident that the experts are still very few with 0.7%, and those with experience in this field already rise to 20.5% and 44.7% with some experience. Those formulators without experience in social projects are represented with 34.1%.

The results at the level of experience validate the fact that when it is not known about technical elements, experts are usually sought, who in turn in the indigenous Cauca context are not many, seeing the need to look for them in other settings. Furthermore, there is a gap between what the formulators have learned from the conceptual academic

point of view and the practices of the same knowledge. This is due to the fact that it is evident that the formulators, according to the surveys, claim to have knowledge in the formulation and evaluation of projects, but when they are faced with real practices such as previous studies, the percentages of those experts or with experiences are lower.

Discussion and conclusions

The degree of knowledge about planning concepts, plans, programs and projects by formulators in the department of Cauca, and who are part of the hierarchical planning chain in Colombia, could be established and in a common way that it is sufficient generally speaking, this is because 50% of this population have high knowledge and 49% know something about it. This result was ratified by the interviewees who stated that the knowledge should be good and/or acceptable. It is considered that the academic environment helps this situation because the professional programs have project subjects, but above all because the universities in the context offer postgraduate degrees in project formulation, evaluation and management from the public perspective.

Regarding the degree of knowledge of the environment, it is not always adequate, in the survey when asking about the difficulty in identifying problems and/or needs, 24.5% have always had difficulties and 61.6% sometimes, turning this situation into high percentages. Knowing the environment implies having clarity and understanding the problem situations and the unsatisfied needs of the population or at least being very close to their understanding. Some reasons for this situation may be occurring because there are some formulators called by the "desk" interviewees who carry out projects from their office, but they do not do field work that allows them to know first-hand the situations that indigenous communities experience. Another reason for the problem of knowledge of the environment is presented, because there are projects that sometimes end up being viable more for political reasons than technical, therefore, despite being poorly formulated, it is still accepted.

It was established that conceptual and theoretical knowledge is not enough when applying it. According to the surveys, it was found that a large percentage of formulators have had difficulties when conducting technical, financial, economic and social studies. Finding a contradiction because the degree of knowledge about projects established that it was good or acceptable. It follows that theory without proper practice is not enough to have a greater chance of success in the world of projects. This situation serves as a call for postgraduate programs related to projects offered by universities, review and strengthen their curricular plans, pedagogies and didactics to deliver professionals with practical and not just theoretical capacities.

In relation to meeting points regarding the formulation, evaluation and management of projects: “the analysis of the environment in a participatory way”; on the one hand, participatory planning is a requirement of the National Planning Department (NPD) and is contained in Law 152 of 1994, Decree 2284 of 1994 and sentence C-524/03; on the other hand, it is interesting to observe that the planning processes in the Cauca indigenous context are participatory and are carried out in what they call mingas of thought, meetings with project actors and creation of councils, among other practices. It is important to mention that the participation of the community allows a greater commitment and degree of motivation in the achievement of the defined purposes.

The General Adjusted Methodology is one of the web tools required by the NPD for the presentation of public investment projects throughout the Colombian territory, it summarizes the generalities of the project and allows it to be monitored, in line with other platforms. In the context of Cauca, it is common to hear about the difficulty of using this platform and indeed the results of the surveys corroborate it, finding that 60.6% of the formulators have not used it and 21.2% have used it with great difficulty. This indicates that both the academy and the territorial entities must deepen their efforts in the correct handling of this tool, otherwise this situation will continue to be a bottleneck in the approval of projects.

It is important to strengthen the concept of integral formulator, which is characterized by those professionals who not only have theoretical knowledge, but have also acquired skills to put into practice the different knowledge learned. Also, of being the one who understands and comprehends the environment where the project will be carried out; in this way, he will be able to have an expert status and thus have a greater probability of success with good management of resources, time and efforts. In addition, this type of formulator must be able to identify problems and/or needs and, based on them, propose coherent solution alternatives so that they are later discussed. On the contrary, the territorial entities should avoid those desk formulators who do the exercise of doing projects without a reliable knowledge of the environment.

The integral formulator must not only be the product of the efforts of the territorial entities and the academy, it must be an attitude of the person, which must be empowered and self-taught; The responsibility it has is of great magnitude, many of the achievements of the development of the indigenous population will be the result of well-formulated projects and in accordance with the real needs of the environment, in addition to complying with the NPD guidelines.

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DETERMINING THE USE OF NOPAL MUCILAGE IN THE CONSTRUCTION IN COLONIAL TIMES (CASE OF CONVENT OF SAN DIEGO)

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Abstract. This research aims to determine the existence or not of organic components from the analysis in mortar fragments of the San Diego convent located in the historic center of the city of Quito – Ecuador. The investigation of the nine (9) samples of mortars were taken from the building that corresponds to the colonial era. The samples are: adobe, floor mortar, and plasters. These fragments correspond to different construction periods ranging from: 1597 to 1700. The present investigation determined that in the mortars analyzed there is the presence of the prickly pear mucilage. To perform an assessment mucilage patterns were obtained. For this two samples of the prickly pear cactus were taken. The first sample was obtained at room temperature, the same one that is light and sticky to the touch. The second one was extracted by means of cooking at a temperature between 90 to 100 ° C. This sample to the touch is much denser and more adherent. Likewise, the use of lime was added by comparing the action of quicklime with

respect to the lime (drowned), which generates additional plasticity in the material. With these patterns the comparison of the model obtained from the old mortars was made; as a result, the patterns that coincide with each other are the spectra obtained by cooking with the one obtained from the old mortars. Therefore, this determines that the nopal mucilage was used in construction in the colonial era.

Keywords: mortars, analysis, mucilage, lime.

DETERMINACIÓN DEL USO DEL MUCILAGO DE NOPAL EN LA CONSTRUCCIÓN DE LA ÉPOCA COLONIAL (CASO CONVENTO DE SAN DIEGO)

Resumen. Esta investigación pretende determinar la existencia o no de componentes orgánicos a partir del análisis en fragmentos de morteros del convento de San Diego localizado en el centro histórico de la ciudad de Quito - Ecuador; se realizó la investigación de nueve (9) muestras de morteros tomadas de la edificación que corresponde a la época colonial, las muestras son: de adobe, mortero de pisos y enlucidos, estos fragmentos corresponden a diferentes periodos de construcción que van desde: 1597 a 1700; la presente investigación determinó que en los morteros analizados hay la presencia del mucílago de nopal. Para realizar una valoración se obtuvieron patrones del mucilago, para esto se tomaron dos muestras de la baba de nopal: la primera muestra fue obtenida a temperatura ambiente, la misma que al tacto es ligera y pegajosa, y la segunda muestra fue extraída por medio de cocción a una temperatura de entre 90 a 100 C°, esta al tacto es mucho más densa y adherente. Así mismo, el uso de la cal fue añadido comparando la acción de la cal viva, respecto a la cal apagada (ahogada) lo que genera plasticidad adicional en el material. Con estos patrones se realizó la comparación del patrón obtenido de los morteros antiguos, como resultado se obtuvo que los patrones que coinciden entre sí son los espectros obtenido por cocción con el obtenido de los morteros antiguos, lo que determina que se utilizó el mucilago de nopal en la construcción en la época colonial.

Palabras claves: morteros, análisis, mucilago, cal.

Introduction

Based on studies carried out in Mexico, where they maintain a tradition of the use of nopal in construction that dates back to pre-Hispanic times, it is assumed that it was used in the manufacture of adobe and lime mortars, due to the great advantages provided by this binder. natural, favoring so that these elements do not have a quick drying, avoiding in this way the breaking of the material and improving its mechanical properties. (Hernández, Coronado, López, & Horta, 2008).

The purpose of identifying the use or not of an organic binder is proposed in this research, in this case the nopal mucilago (*Opuntia ficus)* in existing heritage buildings in the historic center of the city of Quito - Ecuador, it is important to verify whether or not the nopal slime was used in the old mortars.

The use of nopal mucilage in traditional mortars is important since, in combination with lime, it increases its adhesive properties, improves mechanical characteristics and allows mortars to dry more effectively, in addition, it helps retain the moisture that traditional mortars need. to set correctly, and these improve their impermeability to water, particularities that will allow optimizing their use or application in the restoration and protection of heritage buildings.

For this research samples of the San Diego Convent were chosen, this building was considered to be one of the least intervened buildings that retains a high percentage of originality in its construction system and original materials with which they were used in its construction, in addition, there is a great particularity in this building, since it has five (5) well-defined construction periods ranging from the year 1597 to the year 1750, this will help us to identify if in each of the construction periods of the monument the same were used traditional techniques and materials for its construction; For the investigation and analysis of the mortars, the samples were taken, for which authorization had to be requested from the ecclesiastical authorities in charge of the convent, which allowed the collection of only two (2) samples for each construction period that has the building.

Construction periods:

Period 1: Main Cloister (1597-1609).

Period 2: Patio de la Pila Cloister (1700).

Period 3: Patio de la Pila Cloister, North Crossing (1714).

Period 4: Cloister of the Refectory (1731-1734).

Period 5: Novitiate Cloister (1750).

The building of San Diego, despite its years, preserves its majesty, presents a great solidity in its walls and stone columns from the seventeenth century. The different cloisters that make up the building have interior patios that are connected to each other through galleries where you can see the large arches on the ground floor and porticoes on the upper levels, the corridors in the upper galleries are illuminated by means of well-known architectural elements like flashlights. The walls on the ground floor are made up almost entirely of adobe covered by clay plasters and on the upper floor its structure is built in wood that in certain cases are tied with halter and wattle made up of reed and covered by a mud cake, its ceilings are made of reed tied with chilpe, zuro and clay. (Kennedy Troya & Ortiz Crespo, 2010)

Figure 1. Main facade of the convent of "San Diego" Quito - Ecuador.

Note: Own Source, 2019

The Nopal, are shrubby, creeping or erect plants, they acquire an average height of 3 to 5 m in height, in its growth it branches densely, it has a system rich in fine roots that are quite absorbent, it generally grows in arid areas with little rainfall. , the length of the roots depends on the hydric conditions of the land where it is grown, there are many industrial sectors that benefit from the exploitation of nopal, among them is the construction sector that use it as a binder and in the preparation of lime-based paints. (Sáenz, 2006)

In Ecuador it can be found throughout the Inter-Andean region, currently due to ignorance or loss of ancestral knowledge about the handling of materials and traditional construction techniques, its use is only edible from the fruit that the penca produces.

The chemical composition that certain authors cite is the following:

Table 1

Chemical composition of prickly pear

Chemical composition of slime	**Chemical composition of mucilage**
Water 91%, proteins 1.5%, lipids 0.2%, carbohydrates 4.5%, ash 1.3% rich in calcium (90%), vitamin C, carotenoids and fiber	Polysaccharides: galactose, arabinose, rhamnose, xylose and galacturonic acid.

Note: Source: Rodriguez-Felix & Cantwell (1988)

Figure 2. Nopal plant
Note: Own source, 2019

Methods for obtaining patterns

In order to carry out the investigation of the mortar samples obtained from the building, the analysis of the samples of the nopal slime and slaked lime was first carried out in the laboratory.

To study the benefits of nopal, it was necessary to extract the mucilage from the stalk by using two methods, these being cooking and at room temperature, these two techniques were chosen because between the two they present differences in results between Yes, which allows us to establish different properties of the mucilage between each of the procedures, the established methods are:

- Method by cooking
- Soak or standby method

There is no standardization of the proportion for the extraction of the mucilage between water / nopal at room temperature and by cooking the nopales, however, for this research the ratio 2: 1 (water: nopal) will be considered; This emulsion is a thick substance that is obtained from the tuna pallet preserving its properties, for this purpose, the prickly pear trees were selected and collected, from which only certain stems were cut, leaving their main trunk so that in This will sprout new shoots.

Figure 3. Collection of the nopal plant.
Note: Own Source, 2019

For the use of the nopal, first each of the leaves was cleaned, proceeding to remove the thorns to prevent them from adhering to the skin, later it had to be cut into small pieces in the shape of squares of more or less 2 cm in length, this in order to facilitate and obtain a greater quantity of the mucilage from the nopal penca. (Abraján Villaseñor, 2008)

Nopal slime extraction

First method: at room temperature, the cut nopal was placed in a plastic container and then covered with clean water in a ratio of 1: 2, that is, 1 kg of nopal and 2 liters of water, then the container and daily this mixture was stirred in a circular way with a wooden stick, in this case the emulsion of the mucilage was obtained after 2 days. Next, the liquid containing the cactus slime was filtered by gravity using a fine mesh plastic strainer to separate the fibrous residues; By means of this method the nopales can be used for a second time to obtain more mucilage, in this case the process is repeated and the stalk is crushed with a wood to get more quantity of nopal emulsion, by means of this method the The mucilage that is obtained is of a light viscosity and a not very dense texture, but it maintains its adhesive characteristic.

Figure 4. Cutting the nopal leaves and obtaining the nopal at temperature

Note: Own Source. 2019

Second method: the cleaning and cutting process was repeated, the proportions of both nopal and water were maintained, then a cooking procedure was carried out at a temperature between 90-100 ° C for 120 minutes, to extract the greatest quantity of mucilago possible during the cooking period, the nopal was crushed so that it looses as much as possible all the slime that the stalk has, then it was left to rest so that the solids sediment and the liquid was cooled, thus obtaining the mucilage, to separate solid fiber fragments containing fluid filtered by gravity; With this process it was observed that an emulsion containing mucilage was obtained with a thicker and stickier consistency. (Leon, 2010).

Figure 5. Obtaining nopal through the cooking process.
Note: Own Source, 2019

Once the mucilage samples were acquired, both at room temperature and when cooked, they were placed in plastic containers and in the laboratory (INPC), where they were analyzed to obtain their patterns by using the *Infrared Spectroscopy* method.

To determine the chemical composition of the components that make up the different samples of the mortars, as well as the reference substances that they maintain for a possible application in them, this is intended to clarify through the use of the laboratory technique of infrared spectroscopy, and in the same way obtain as much analytical information as possible about its ingredients. To carry out the analyzes and proceed to obtain the patterns, different mortar samples were used, these correspond to different periods of construction of the San Diego convent.

Description and location of samples

Figure 6. Delimitation of the construction periods of the San Diego Convent with the sample points
Note: Own Source, 2019.

Table of location of the points that indicate the origin of the samples in the building of the mortars analyzed:

Table 1
Sample Location

Number	INPC code	Sample / Location	Observations
1	07-19-5	Arch Cemetery Mortar Restoration 2007	It was subjected to an ethyl acetate treatment after reading
2	07-19-6	Cemetery Wall Mortar	It was subjected to an ethyl acetate treatment after reading
3	07-19-7	Mampuesto Mix of the Enclosure (adobe)	It was subjected to an ethyl acetate treatment after reading
4	07-19-8	Pario de la Cruz mortar, east corridor	It was subjected to an ethyl acetate treatment after reading

5	07-19-9	Wattle mortar patio of the pile 2nd floor (east)	It was subjected to an ethyl acetate treatment after reading
6	07-19-10	Bahareque mortar patio of the pile 2nd floor (north)	It was subjected to an ethyl acetate treatment after reading
7	07-19-11	Modern repair mortar cladding	It was subjected to an ethyl acetate treatment after reading
8	07-19-12	Mortar to set the 2nd floor pastry floor	It was subjected to an ethyl acetate treatment after reading
9	07-19-13	Mortar Masonry theater access room 2nd Floor	It was subjected to an ethyl acetate treatment after reading

Note: Source: INPC Laboratory and Analysis Unit, 2020

Results

Organoleptic analysis of materials

To carry out the organoleptic analysis of the materials of both additives (nopal mucilage) and the binder (lime), the samples were provided:

- Nopal mucilago, obtained at room temperature and by cooking.
- Lime, quicklime sample and hydrated lime (slaked)

Nopal. - To know the physical state of the sample, two types of Mucilago samples were used: the nopal slime was obtained at room temperature (decomposition process) and the other sample was cooked at an average temperature of 80 ° C.

Physically these samples show differences. In the case of mucilage "cooked" at 80 ° C, it was observed that it is more viscous, and its sensory adhesion capacity is better compared to macerated mucilage, which is lighter in appearance. The mucilage has a main characteristic that is the viscosity, for our case, the same that is projected to be used in the application as an additive for use in construction and paints (Vargas-Rodríguez, et al., 2016)

Figure 7. Mucilage cooked at 80 ° C, and its effectiveness as an adhesive.
Note: Own Source, 2019

Lime.- binder that has its own natural adhesion and cohesion qualities to bind aggregates, and that notices a chemical reaction that hardens it, in this case it was provided:

- Quick lime powder.
- Slaked lime.

Quicklime is found in nature as limestone, this is obtained by processing it in ovens at high temperatures, in this action it is when it releases CO2 and the so-called "quicklime" is obtained, which is highly reactive in contact with water, resulting in a lumpy material.

Slaked lime [Ca (OH) 2], which is obtained as a result of having immersed quicklime in water for a period of time, the longer the slaking cycle, this will improve its purity, it is also known As "calcium hydroxide", as a result of this process it is presented as a fine paste with a purity of between 70 and 80%, qualities that determine its use in construction or in preparing canvases for painting. (Villalobos Ruiz, 2014)

Mud, its main components are feldspars, it is a mixture of sodium, potassium and calcium aluminosilicates, mainly with low quartz content (<12%), consistent with the mineralogical composition of the sedimentary soils of the inter-Andean valley.

Materials analysis by infrared spectroscopy

The laboratory uses the specific test procedure PEE-LAB-INPC-04 for Analysis by Infrared Spectroscopy FTIR-ATR1. This technique uses radiation in the infrared range and through signals in the form of peaks, which allow us to identify certain functional groups or molecular interactions, and in this way determine the substances to be investigated.

In some cases, due to the interest in certain functional groups, it is necessary to extract them from the matrix that contains them, for this the principle of elutropic series (solubility series) applied in liquid chromatography is used.

Analysis of standard or reference substances

The reference substances obtained were mucilage obtained from nopal and lime. These substances, as indicated on the labels, were subjected to different physical and chemical treatments in order to improve certain mechanical properties, adhesiveness and cohesion.

The samples in aqueous medium cannot be measured with the FTIR-ART equipment, because the water interferes with the signals of the samples. In order to carry out the readings

without interference, the excess liquid of these substances is evaporated, and they are immediately placed on the ATR glass in order to obtain a suitable spectrum.

In order to adapt the samples to the protocols used in the laboratory, a code was provided for each one of them. This information is presented below in the following table.

Table 3
Reference Substances

INPC code	Sample	Observations
07-19-1	Mucilago extracted from nopal in water, heated to 90-100 ° C	It was subjected to an evaporation treatment for its reading
07-19-2	Mucilage extracted from nopal in water, by macerating for 7 days	It was subjected to an evaporation treatment for its reading
07-19-3	Lime slaked for 18 months	It was subjected to an evaporation treatment for its reading
07-19-4	Quicklime	No treatment

Notes: Source Laboratory and Analysis Unit INPC, 2020

Mucilage

The measurements made were made with the FTIR-ATR equipment, whose results are presented in Transmittance vs. wave number. The signals indicated in figure 9 are the product of molecular interactions (spectral vibrations), which the mucilage presents against an infrared beam. These data indicate that there are small variations between mucilage obtained at 80 ° C (cooked) and mucilage at room temperature. It can be seen that cooked mucilage has a larger signal around 1000 cm-1 compared to uncooked mucilage.

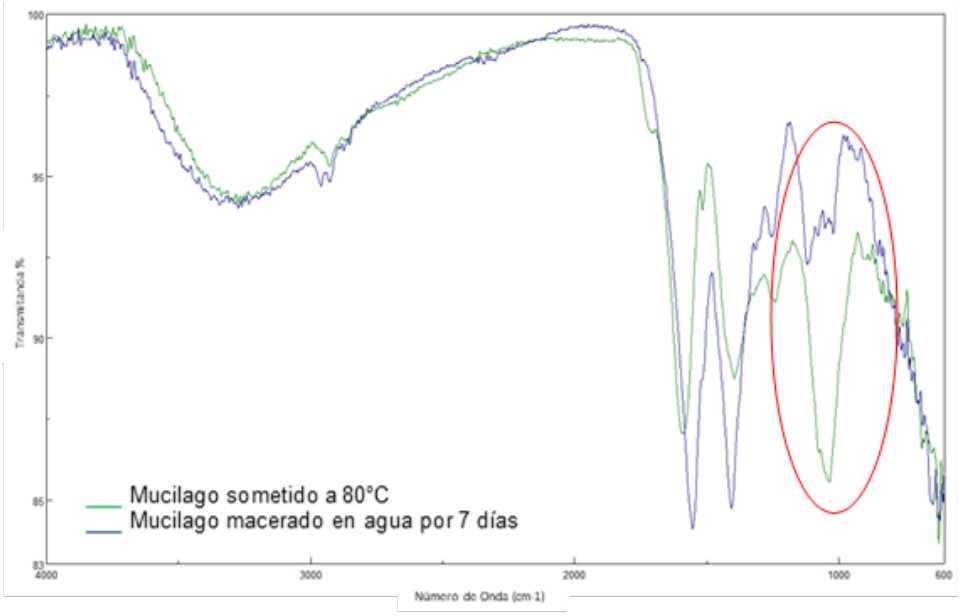

Figure 8. Spectra of mucilages obtained by FTIR-ATR.
Note: Source: INPC Laboratory and Analysis Unit, 2020

In order to interpret the previous result, the peaks found in the spectrum of mucilage cooked at 80 ° C are described.

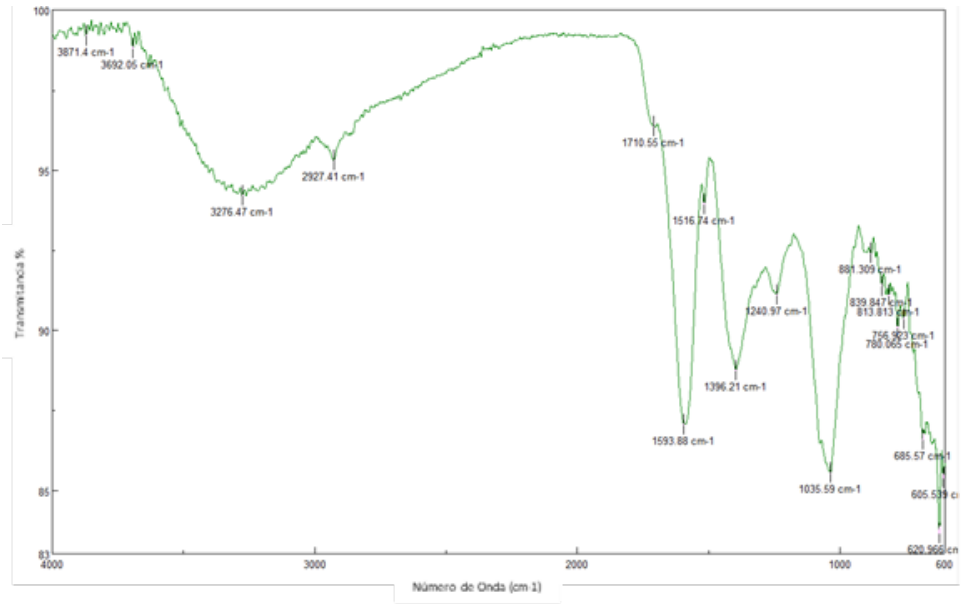

Figure 9. Mucilage spectrum subjected to 80 ° C (cooked) obtained by FTIR-ATR..
Note: Source: INPC Laboratory and Analysis Unit, 2020

Also, the mucilage is subjected to the previous procedure at room temperature macerated for 7 days.

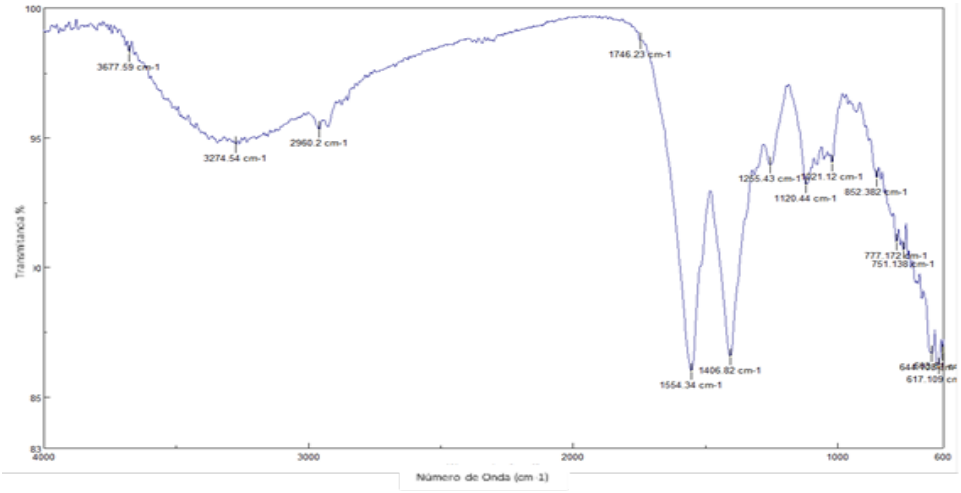

Figure 10. Spectra of mucilage macerated in water for 7 days obtained by FTIR-ATR.
Note: Source: INPC Laboratory and Analysis Unit, 2020

The FTIR-ATR spectrum of various types of mucilages are characterized by having a reading of values2 ranging from 1000 cm-1 to 2000 cm-1, it identifies the largest number of chemical groups that provide information that can be used to differentiate the different types of mucilages. According to bibliographic sources, the presence of these functional groups can be explained in the following way.

The presented spectra present signals or stretching bands in OH alcohol groups (3100-3600 cm-1), they appear due to the formation of hydrogen bonds of these functional groups, these vibrations, together with the signals of CH, CH2, CH3 (methyl, methylene and methine group) which are stretch bands (3000–2800 cm -1).

The strongest signals occur in the common fingerprint region of polysaccharides or carbohydrate units (1300–1050 cm − 1). As well as the 1200-1800 cm-1 region of the carboxyl group state.

However, the region between 1000-2000 cm-1 identifies the greatest amount of chemical groups, which provides information that can be used to differentiate the different types of mucilages.

Between the wave numbers of 1200 to 900 cm-1 there are monosaccharide and polysaccharide type sugars, at 1750 cm-1 aldehydes typical of sugars are present, at 1100 cm-1 there are esters associated with these same sugars that are part of the mucilages. These sugars are called arabinose, rhamnose, galactose and xylose (Aguilar Reynosa & Rodríguez, 2010). These sugars guarantee adhesiveness and cohesion together with other elements that make up the mortar.

Quick lime and slaked lime

These substances were subjected to a drying treatment to eliminate excess water that interferes with the analysis. The readings below are adjusted to determine spectral similarities and differences between these two materials. Concordances can be observed in three peaks of the patterns, these are located approximately at 3600 cm-1, 1400cm-1 and 800 cm-1, which are presented in the following figure.

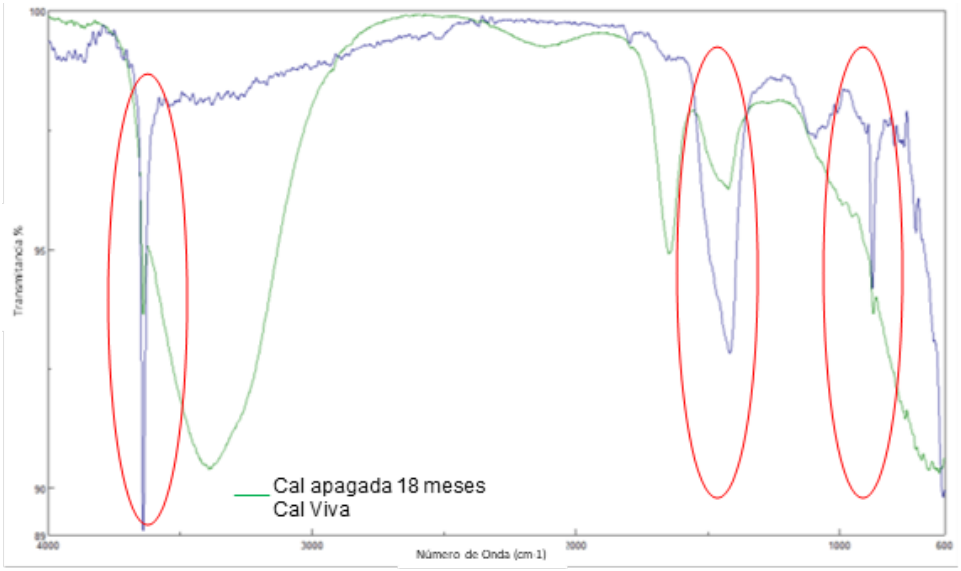

Figure 11. Spectra of lime types obtained by FTIR-ATR.

Note: Source: INPC Laboratory and Analysis Unit, 2020

To identify the different anomalies or changes in the spectral readings, the quicklime and slaked lime are read separately, being able to obtain the wave number values individually, which allows us to obtain an adequate identification of them.

The infrared spectrum of slaked lime is presented below

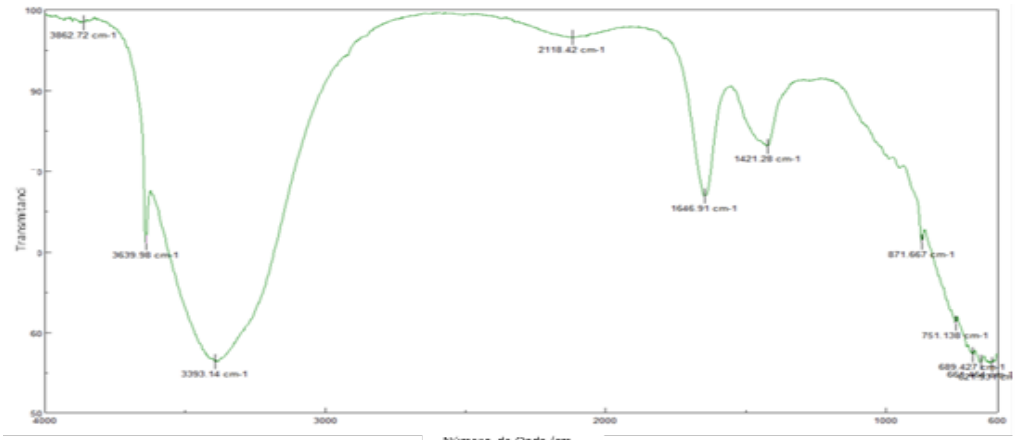

Figure 12. Spectrum of slaked lime obtained by FTIR-ATR
Note: Source: INPC Laboratory and Analysis Unit, 2020

Likewise, quicklime has the following wave number values, as indicated in the following graph.

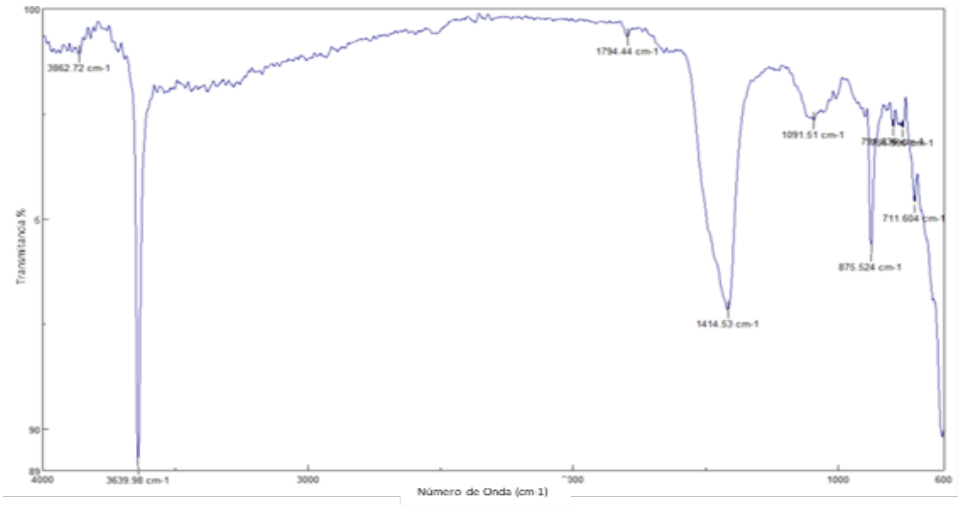

Figure 13. Spectrum of quicklime obtained by FTIR-ATR
Source: INPC Laboratory and Analysis Unit, 2020

Mortar Samples

As the samples are in solid state, it was necessary to extract the substances of an organic nature. For this, the protocol for handling organic samples in soil recommends extracting the samples with ethyl acetate, due to its intermediate elution strength (0.58 in the Snyder3 series), very commonly used in chromatographic separations. For this reason, the solvent should only drag the possible related organic substances found in the samples and read them after their evaporation. For the analysis by FTIR-ATR, the spectral region between 1800 to 600 cm-1 corresponding to

the fingerprint area of the spectra was used. Not all the infrared spectral area measured provides us with information to compare. That is why, the measurement area of the spectra is restricted and, in a more didactic way, they will be separated in scales of the graphs in transmittance vs wave number.

On the basis of the FTIR-ATR spectroscopy analysis, the different spectra were compared with the reference substances (cooked mucilage4 and slaked lime), prepared exclusively to determine their possible production technology. Through the "Knowitall" software, we can compare and superimpose these spectra digitally.

Almost all the samples show the same peaks as the nopal reference at 80 ° C. There were only two samples that were unrelated, these were: modern repair mortar for the enclosure, mortar for laying the 2nd floor pastry floor. This information is presented in the following graph.

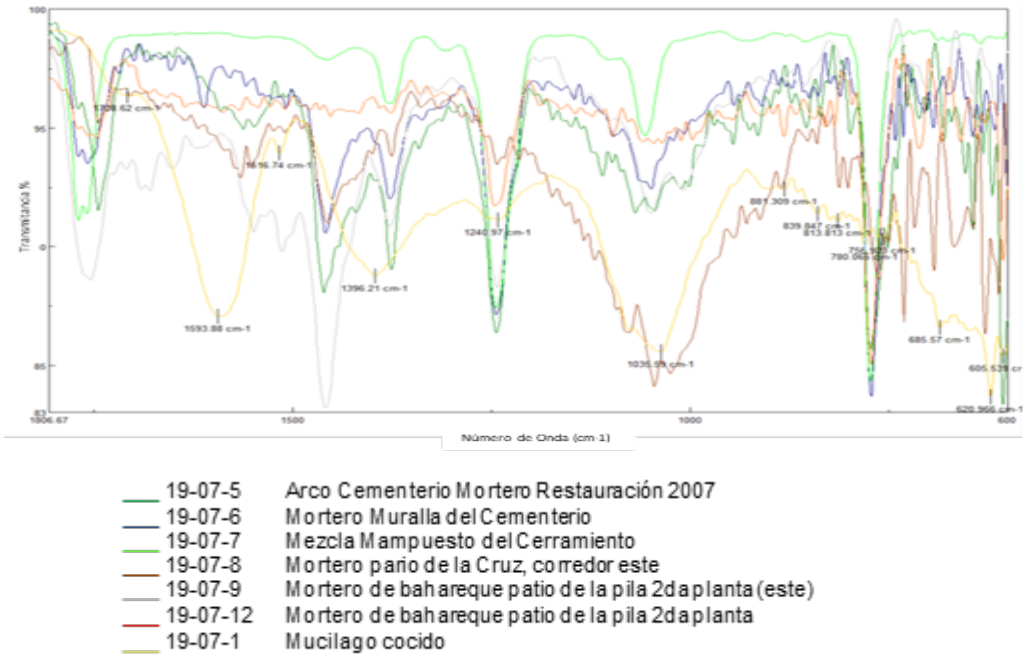

Figure. 14. Spectra the samples vs the cooked mucilage
Note: Source: INPC Laboratory and Analysis Unit, 2020

The information that matches the spectra of nopal with the samples is detailed below. In this case, it was determined that the spectra corresponding to the sample areas: bahareque mortar patio of the 2nd floor pile (north) and mortar masonry, access room to the 2nd floor theater, had bands in 1455.99 cm-1 that are Alcohols (CO), 1375.96 cm-1 (CO) corresponding to esters and 1102.12 cm-1 (HO-COO) which are carboxylic acids. Despite having an organic nature, in themselves they do not define, like the rest of the spectra, a possible addition of binding materials such as mucilage.

A more detailed way to identify the spectra is to compare each of the samples against the reference substances, such as mucilage and slaked lime. We will divide the spectral ranges into groups and we will also differentiate the organic components and the lime.

Spectral range from 1520 - 1500 cm-1

The mucilages have a remarkable characteristic in different spectral bands, to begin with, the peaks shared by the samples and the mucilage can be observed at wave numbers 1593.88 cm-1 (NH) that correspond to amino, 1516.74 cm-1 (CO) corresponding to alcohols.

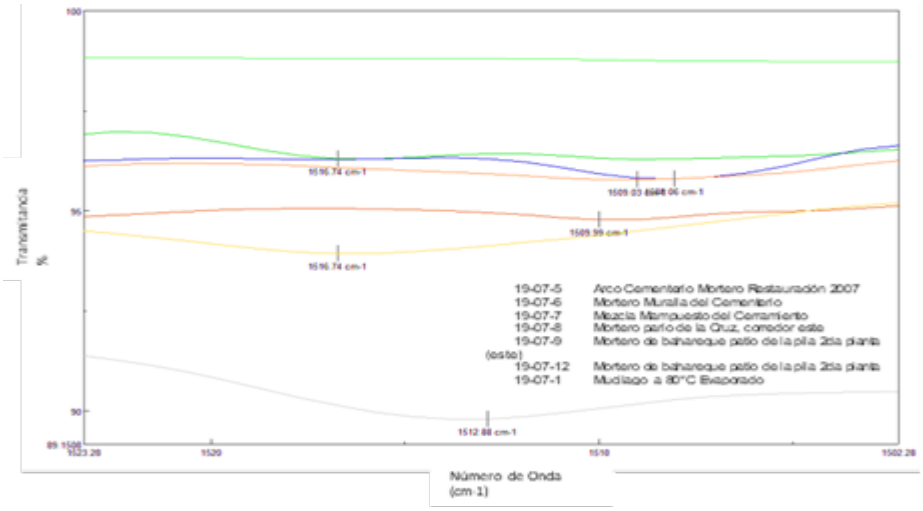

Figure. 15. Spectra of the samples vs the cooked mucilage range between 1520-1500 cm-1.

Note: Source: INPC Laboratory and Analysis Unit, 2020

Spectral range from 1450 - 1300 cm-1

To verify the existence of alcohols and esters, this range is chosen within the spectrum. What was identified was that there is another band that corresponds to a mucilage component located at 1396.21 cm-1 (C-O) and corresponds to an ester.

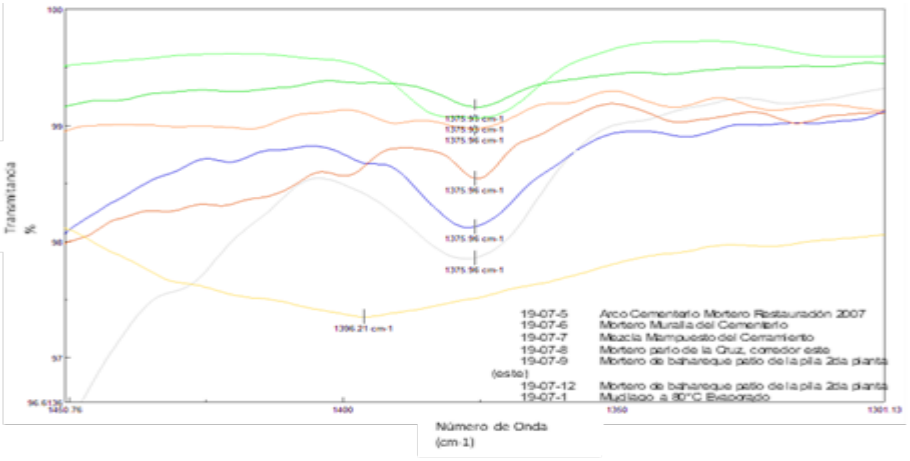

Figure. 16. Spectra of the samples vs the cooked mucilage range between 1450-1300 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Spectral range from 1300 - 1100 cm-1

Within this zone, the functional groups of carboxylic acids are found, in peaks around 1240.97 cm-1 (HO-COO).

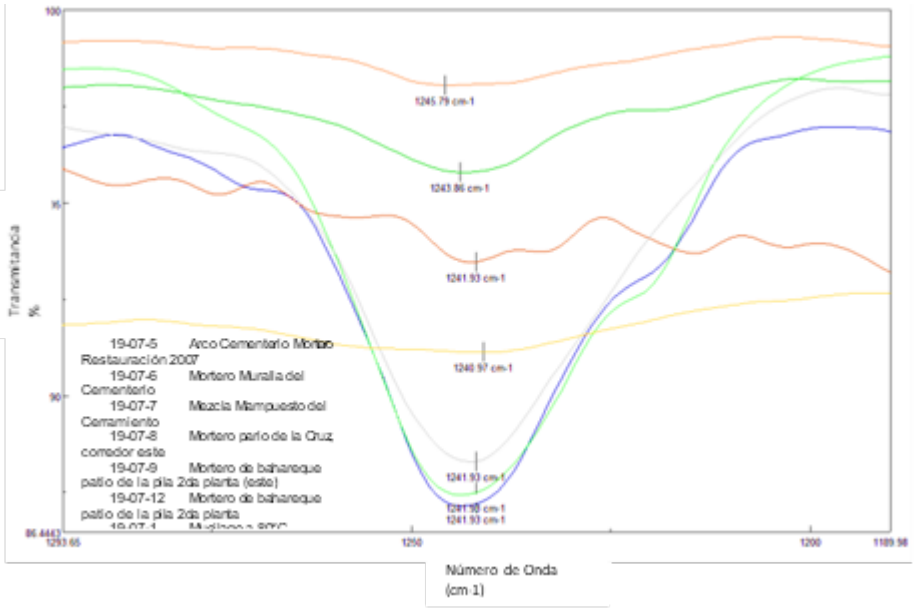

Figure. 17. Spectra of the samples vs the cooked mucilage range between 1300- 1100 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Spectral range from 1100 - 960 cm-1

This spectral zone is one of the most important since alcohol groups are manifested. In the peak located at 1035.59 cm-1 (C-O) they correspond to this group, located in the reference substances and in all the samples.

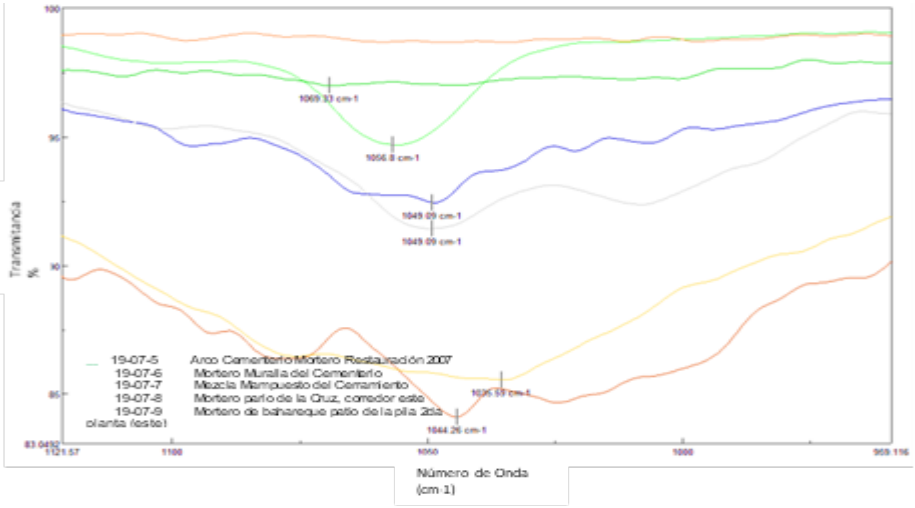

Figure. 18. Spectra of the samples vs the cooked mucilage range between 1100-960 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Spectral range from 960 - 600 cm-1

Finally, in peaks at 771 cm-1 (C-C) that correspond to branched carbons, 685.57 cm-1, and 621 cm-1 (C-C) that belong to linear carbons, compounds that are part of mucilages.

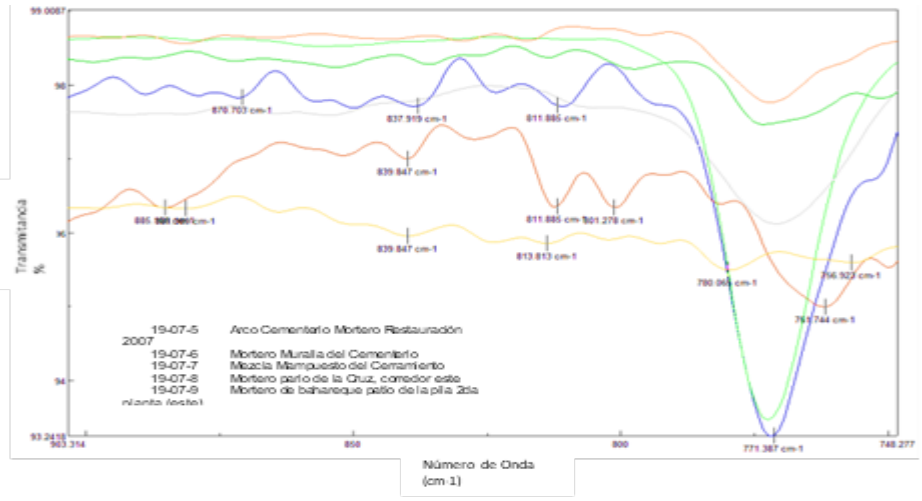

Figure. 19. Spectra of the samples vs the cooked mucilage range between 960 - 600 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

For the analysis of the presence of lime, the slaked lime standards were also compared with the samples delivered to the laboratory. In all cases there is the presence of lime in the mortars. To illustrate, the standard of slaked lime will be shown for months, with the samples of the arch cemetery mortar restoration 2007, the mortar of the cemetery wall and the mortar of the enclosure, which are equivalent to the mortars of the oldest construction stage.

The samples that do not contain the main nopal peaks themselves have been compared with slaked lime, the results are shown below.

Spectral range from 3700 - 2760 cm-1

We can see that the peaks at 3640 cm-1 corresponding to a Ca-O-H bond, typical of hydrated lime, in addition to a peak at 3400 cm-1 typical of an O-H bond.

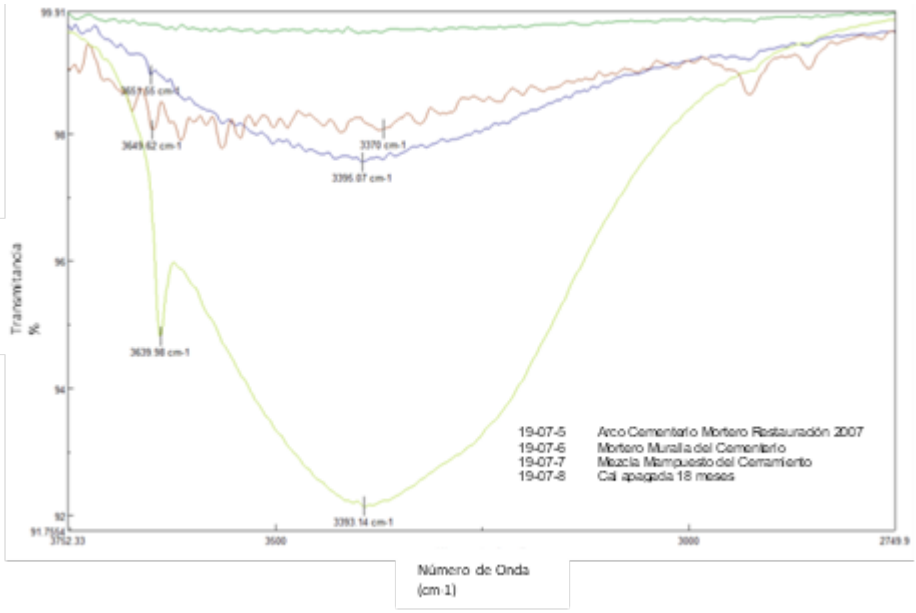

Figure. 20. Spectra of the samples vs slaked lime range between 3700 - 2760 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Spectral range from 1560 - 1270 cm-1

Within the same spectra, we can see that at 1647 cm-1 there is a Ca = O bond.

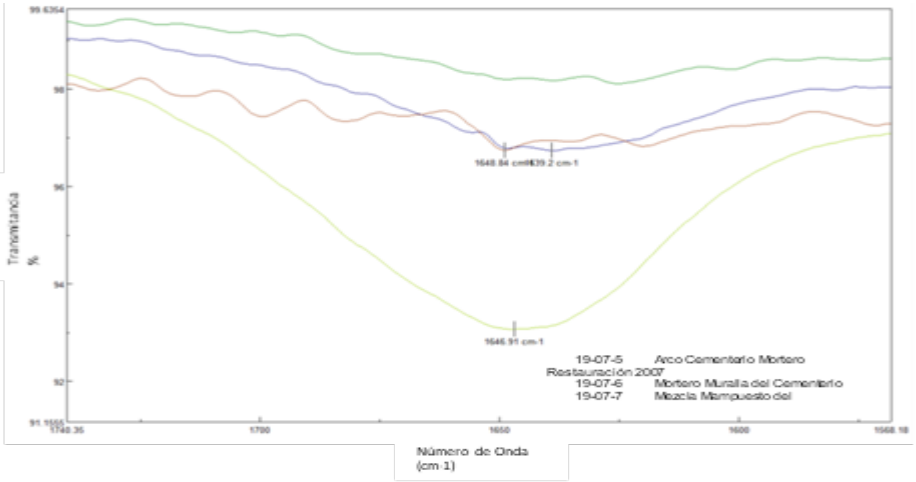

Figure. 21. Spectra of the samples vs slaked lime range between 1740 - 1560 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Rango espectral desde 1560 – 1270 cm^{-1}

In the analysis there is also another peak at 1420 cm-1 that corresponds to Ca-O

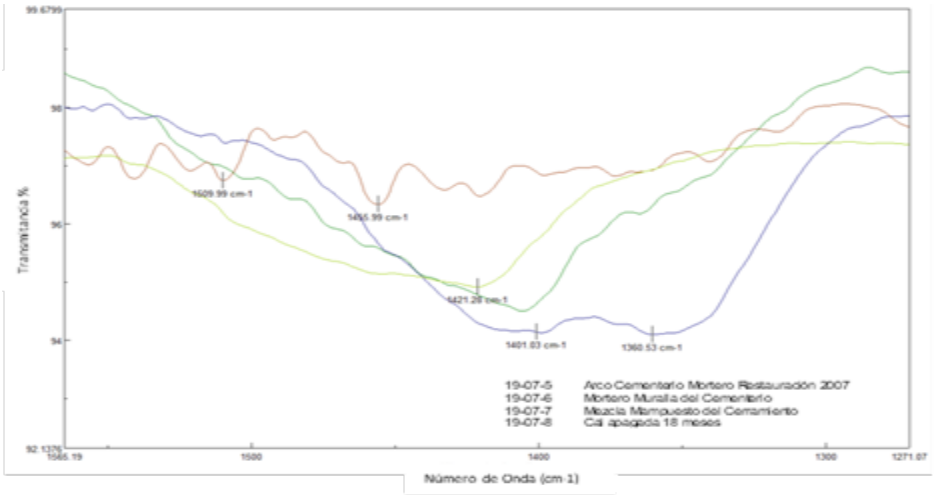

Figure. 22. Spectra of the samples vs slaked lime range between 1560 - 1270 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Spectral range from 880 - 600 cm-1

Finally, there are not so well defined peaks, whose bands are at 870 cm-1, 750 cm-1 and between 680 to 620 cm-1, whose bonds could correspond to Ca-O bonds.

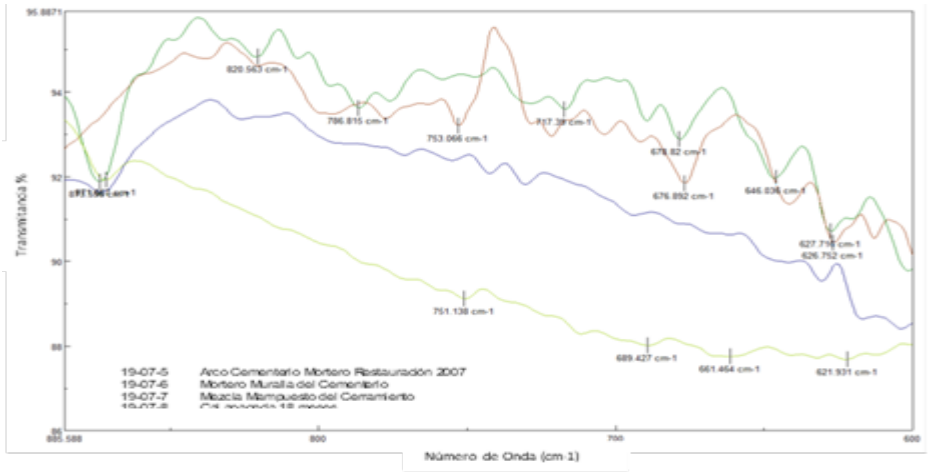

Figure. 23. Spectra of the samples vs slaked lime range between 880 - 600 cm-1.
Note: Source: INPC Laboratory and Analysis Unit, 2020

Summary of results and discussion

In summary, the 1455.99 cm-1 bands correspond to alcohol (CO), 1375.96 cm-1 (CO) ester and 1102.12 cm-1 (HO-COO) carboxylic acid present in the samples Patio bahareque mortar of the 2nd floor pile (north) and Mortar Masonry, access room to the 2nd Floor theater. The bands

shared by the samples and the mucilage are: 1593.88 cm-1 (NH) Amino, 1516.74 cm-1 (CO) Alcohol, 1396.21 cm-1 (CO) ester, 1240.97 cm-1 (HO-COO) ac. Carboxylic, 1035.59 cm-1 (C-O) Alcohol, 771 cm-1 (C-C) branched carbons, 685.57 cm-1, and 621 cm-1 (C-C) linear carbons.

From the results set forth above, the functional groups found correspond to organic materials of natural origin, associated with nopal due to the similarities found to the measured pattern. This nopal compared was the one that was previously at boiling temperatures, dissolving these sugars and leaving them in solution. Once this mixture is obtained, it is easier to spread together with straws and clay, to obtain an optimal mortar in a suitable proportion.

The combination used in the mortar, in an appropriate proportion, manages to improve thanks to the properties of sugar, certain mechanical properties, adhesiveness and cohesion.

P Based on the foregoing, it can be ensured that the analyzed mortar samples contained organic matter similar to prickly pear under heating, these samples correspond to: arch cemetery mortar restoration 2007 (07-19-05), cemetery wall mortar (07-19 -06), mixture of masonry of the enclosure (07-19-07), east corridor patio mortar (07-19-08), adobe mortar patio de la pila 2nd floor (east) (07-19-09) , wattle and daub mortar 2nd floor pile patio (07-19-10).

Conclusions

It can be assured that the analyzed mortar samples contained organic matter similar to nopal, these samples correspond: to the arch of the cemetery mortar used in the restoration of 2007, mortar from the cemetery wall, mixture of the enclosure masonry, mortar from the cross, from the east corridor, wattle and daub mortar from the patio of the 2nd floor pile (east), bahareque mortar from the patio of the 2nd floor pile.

The spectral analysis of the previous mortar samples and the pattern of cooked mucilage coincide in a high percentage, which is why we can assert that they share the same chemical behavior.

Through the organoleptic analysis it was possible to appreciate the overall behavior of mucilage and lime in an unknown proportion, it provides better plasticity, adhesiveness and maintains the humidity of the mortar, which is why they persist until today, with a minimum degree of deterioration .

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