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Analysis of BIM Methodologies Applied to Construction SMEs. Case Study: Cuenca- Ecuador

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Abstract:- The variables analyzed during this research, allowed to study the process and the management strategies used in architectural projects by construction SMEs in the city of Cuenca – Ecuador. Lot of variables were found out, such as the number and frequency of construction projects they have per year, type of objects they carry out among other variables. This research found out strategies and recommendations by applying research methods during the investigation. They could be applied in SMEs of Cuenca city as it is the study case. It could be done by interrelating the variables found in the study of similar cases from other countries and the variables found in the interviews process done to experts located in Cuenca city. The research improves an analysis of BIM methodologies with BIM processes too. This processes could guarantee an efficient management model in which, time and resources are optimized to obtain high quality projects in architecture projects. The proposed processes were carried out based on the study of the development that architectural projects have had throughout history, remembering the vision they used to apply in the past until now. It includes tools that allow to reach complete and interdisciplinary projects while they involve other professions so that they can be designed in an optimal and efficient way to achieve as result: quality architectural projects with high standards.

Keywords:- *BIM, Construction SMEs, Architecture.*

I. INTRODUCTION

This study analyzes and compares through a qualitative analysis the management models used in small and medium enterprises that are specifically dedicated to construction activities. The data collected will support the implementation of a methodological proposal with BIM processes that could be input in Cuenca City SMEs. This method could be tried by making a pilot study in mentioned enterprises. It also includes strategies and recommendations that will serve for future studies and applications for the city in order to guarantee an efficient management model in which time and resources could be optimized to obtain and achieve projects with high quality standards. The use of this method and strategies bring out solutions from an integral vision and will make the construction sector get integrated in bids at an international level. Foreign investment can be increased and constructors will be supported by public regulations that are included and obligatory from the highest commands such as the government and the local municipalities that are the ones that regulate the constructions and the projects that are carried out in Cuenca city.

A. Construction small and medium enterprises in Ecuador

In Ecuador, small and medium enterprises (SMEs) that are in the market come in all shapes and sizes, having the freedom to develop any type of activity where utility is sought. Per information from the Study of Competitive Management of Small and Medium-Sized Enterprises in the Republic of Ecuador, they represent 95% of the productive units [5].

The concept of SMEs differs in its acronym in small spaces from one country to another, because although it is true that the base of small and micro enterprises embrace the same elements, it will depend on the level of development of each nation to establish equality or inequality in them. For example, a small business in Switzerland can be a large one in Ecuador. SMEs have organizational structures that adapt more quickly to changes in the economy and the positioning of socioeconomic strata. However, there are critical points of small and medium enterprises in Ecuador, in which they have not advanced. Two fundamental aspects are the purchase of first generation machinery (they keep computerized programs inserted in their machines); and, that their financial and sales areas do not work with software that optimizes their work times, thus achieving to minimize costs to maximize profits [12]. By not having technology or computer tools that allow these companies to improve and optimize productivity and planning, management and execution of construction activities, they immediately place themselves at a competitive disadvantage.

These types of companies have organizational structures that adapt depending on the changes and the economic situation that the country presents them, that is why in most cases they are forced to involve and add technological

resources of the highest quality, in order to achieve greater productivity and at the same time, achieve competitive advantages over other companies while having better opportunities within the public and private sector.

The construction sector is among the most important for the country, according to the aforementioned study, in 2019 it represented 8.17% of the real national GDP ($5,874 million). It also generated about 6% of total employment and attracted $69 million in foreign direct investment. In addition, construction demands more than $1.9 billion annually from the public and private financial system, which is why it makes a significant contribution to the economy in terms of investment, production and employment.

The way to conceive an architectural project that is intended or not to be built has been changing over time because there are now different and diverse ways to address them. In ancient times, the way to communicate a project was in sheets of paper, today there are several technological tools that can facilitate the process and allow the architect to optimize time, resources and make fewer mistakes. It is also possible to create a virtual environment of collaborative work with other disciplines related to architecture that are often present in most projects through the application of the BIM Methodology (Building Information Modeling), used today in several SMEs construction internationally. "It is true that there is a challenge, at the time of changing paradigms in which BIM strategies are included, so that architectural construction processes can be led to the elevation of quality indicators in the construction sector, since the competitive advantages of BIM on platforms such as CAD show significant savings in investment projects" [6].

To adapt to competitive advantages and to improve their productivity and opportunities within the public and private sector, SMEs must achieve forms of management that allow them to continue growing their business and at the same time improve their profits. The experiences of analogous cases that SMEs presents in other countries show that architectural projects are being worked with collaborative methodology online now.

Construction projects involve a large amount of resources and time, which if not are properly managed, it is not possible to achieve satisfactory or optimal results. Today there are several technological tools that have been improved and developed over time, through the experience that architects and builders have been obtaining throughout history, in the planning and management of their projects and constructions. At the time of approaching a project, it is quite common the simultaneous participation of several experts in the planning, design and execution of an architectural project that in general and in almost all the cases involves and requires different branches of professionals specialized in their respective areas, to be approached in an integral way with effective and productive results.

B. Architectural project management and BIM process implementation

The administration or management cycle begins with planning where the operations and actions that must be executed to carry out the technological transformation of the inputs are defined. If the planning has been done effectively, it is possible to control the construction [2]. That is why most companies face problems caused by the lack of planning, mainly related to compliance with the execution time and the timely supply of materials. The execution of a project involves many operations to transform various resources that can only be achieved through the work of several organizations in a timely manner. Thanks to the technologies and technical tools that exist today, an architectural construction project can be faced at such a complex level where the participation of experts in different disciplines can be combined simultaneously in the development of a project, which traditionally was carried out from consulting meetings or the comparison between plans prepared by different experts. Nowadays the simultaneous participation of several experts in the design of a project is possible architects, engineers and specialists in technical studies can design and plan on the same document where the constructive project is taking shape virtually. The project to be conceived is in a server that does not necessarily have to be in any of the offices of the experts, as was required in the past, this project can be altered according to the role assigned to each specialist, this is based on the management system for construction projects from BIM. The competitive advantages of BIM over platforms such as CAD show significant savings in investment projects [6].

Building Information Modeling (BIM) is one of the latest technologies revolutionizing the architecture, engineering and construction (AEC) industry worldwide [11]. Building Information Modeling (BIM) is a process of improvement and innovative tools for visualizing design phases, coordinating projects and communicating drawings and documentation in the construction industry that allows the creation and improvement of all aspects of a building before the construction stage begins. Building information modeling represents a new era in the combination of innovation and technology in architecture, involving the planning and design stages. BIM is not only a tool or software that illustrates a drawing and documentation composition, it is a multifunctional use in which one can work from a conceptual form to the construction detail, in a totally collaborative way involving other related disciplines that are part of it, including areas such as interior design, as it has been applied by most first world countries in the construction industries, such as USA, Australia, Hong Kong, Finland, Europe, Middle East, India and Singapore [5]. The implementation of BIM is a potential idea that allows to solve existing problems such as cost, time, documentation, quality and efficiency in the progression of work [4]. This represents a challenge and a change of mentality in the face of the traditional way in which construction projects were managed, since BIM requires a change in the way of working. For this it is necessary to have training in the processes, to ensure that all employees have the required level of knowledge [1], and also to guarantee as a company, the availability of compatible

software and adequate hardware to achieve a collaborative work with all the actors involved in the projects, taking into account the different discipline that may arise within the process.

C. BIM in academic and professional training.

Moving from teaching the traditional basic design to teaching the architectural construction project as an information management system implies strengthening the professionals of the construction sector in information technology management. It is a challenge and a complex process, but it means nothing different from preparing professionals for a new global context that requires training strategies that prepare professionals not only for the local, but also to face global competition. And for this, understanding the importance of architecture as a subject of an information management system is fundamental [6].

For BIM to be successful in its implementation, all industry players must be informed about the potential benefits for their profession [5]. The deficiency of planning in the constructions leads to unsatisfactory results for both the construction company and the investor, since there is not always a correct management of systems or processes that allow to program and manage a project in a timely manner. This is even though 68% of construction companies use some type of software in the planning of the projects, as mentioned in the case study "Diagnosis on the planning and control of projects in construction SMEs", conducted in Yucatan, Mexico in 2010. This document also highlights the urgent need for SMEs to improve the planning and control phases of projects to make them more complete and comprehensive.

II. METHODOLOGY

The methodology selected in this study was based on qualitative research. Since it focuses on: “understanding phenomes by exploring them from the perspective of the participants in a natural environment and in relation to the context or the central problem of interest, which makes it possible to focus on a phenomenon, concept or idea that you want to explore and understand in greater depth" .The possible or not relation of qualitative variables between various concepts are part of the studied problem, such as the number of architectural projects, the planning phase, management and duration of the projects that are presented and are part of the process, in the different stages of architectural projects that they carry out in the construction. This methodology was chosen in order to be able to relate variables that obtain a deep understanding of the studied situation as people present us in order to claim the voice of the informing subject and make the phenomenon in question understandable, and get involved in the local community daily problems for investigative purposes [8]. Within the incorporation of BIM processes (Building Information Modeling) and within the architectural construction projects that SMEs (Small and Medium Enterprises) of the construction in the city of Cuenca – Ecuador face.

The integration of BIM methodology in the construction process represents a challenge of change of traditional paradigms, it also represents several factors such as interdisciplinary and teamwork with new actors, communication of stakeholders, managed from a constructive vision, which will allow conceiving architectural projects in a virtual but fully integrated work and at the same time to have better proposals to optimize time and costs in the works to be executed by the builders. "It is true that there is a challenge, at the time of changing paradigms that include BIM strategies, so that architectural construction processes can lead to the elevation of quality indicators in the construction sector, since the competitive advantages of BIM on platforms such as CAD show significant savings in investment projects" [6]. The management models that can be appreciated and that are used in the development processes of architectural projects in the SMEs of Cuenca city, contain qualitative variables such as the quantity and frequency of projects that they have per year, type of projects that they carry out, time of the company economically active in the market. There are also, other variables that were discovered with the analysis of similar international cases of SMEs that applied BIM processes (Building Information Modelling) and that are pioneers in the integration of technologies for collaborative working online. Those cases, are serving as an example to implement BIM processes through the correlation of qualitative variables collected in the research process and that exist in Cuenca city, which after being analyzed can guarantee an efficient management model that finally optimizes time and resources to obtain projects with quality standards that provide solutions from a real vision.

A. Participants

Eight experts interviewed were selected for being within the city of Cuenca, active in the Chamber of Construction of Cuenca which is an authorized entity that regulates the activities of constructor with the support of public politics too. They all have done about 500 projects throughout their career. They are known because of the quality they bring to their architectural projects that have been executed, some of them are: “Las Praderas de Bemani Condominium”, Roshental Housing Complex, Villablanca Condominium, Mediterraneo Towers. One of the more important requirements to be selected as an expert candidate to be interviewed was that they had to comply at least 10 years of working experience as a SME, and of course they had to be active in the construction sector.

Followed by this, the reliability and validity was evaluated based on interviews with open questions, to experts in the area, applying the desired level of confidence, which was carried out within the concepts to be mentioned, for example: the experts were located in SMEs of Cuenca who was the universe of study, because they got the requirements of qualitative variables that were studied and because they got enough experience in the construction sector.

B. Gathering data and instruments

Through interviews and the literary review of analogous cases with a scientific report, the possible relationship of these qualitative variables with existing variables in SMEs in developed countries and South America is analyzed, and qualitative factors that influence and see the construction companies in the city of Cuenca. In this way, it is possible to understand in a comprehensive way, those reasons and existing relationship to understand why construction companies fail to carry out adequate and comprehensive prior planning in the projects they have to face as companies.

Case analyses.

We analyzed similar international cases of SMEs that have applied BIM (Building Information Modeling) processes and their implementation experiences. The analyzed cases where chosen because were countries that applied BIM, in small and medium enterprises. We excluded those cases in which qualitative information was not found and those that did not implement BIM in SMEs. After doing a literature review about the topic, we have included developed countries that are pioneers in the field at the moment and also in countries located in South America, which are beginning this type of collaborative processes online, since this topic is relatively new.

We selected analogous cases to look up how qualitative variables could interrelate and could be different in the companies because they got developed in different context and environment. Those factors let us understand in depth how qualitative variables will be specific and precise in each SME case so they will have a different analysis respectively. Even though, in the process we found some common variables that were similar to qualitative variables found in Cuenca city, one that can be mentioned is the fear from professionals to change the traditional way they tackle their projects.

Interviews.

Fourteen open questions were asked during the interviews. The way the questions were asked was made in order to know and relate the existing qualitative variables and their interrelation. With the experts experiences we could understand the reality that builders face in Cuenca City when architects or engineers in the area start a planning, execution and maintenance phase or process during an architectural project (see Fig 1.)

Fig. 1. The questions that were made in the interviews with experts.

C. Data analysis

The management models and administrative and planning processes used in the architectural projects by the SMEs (Small and Medium Enterprises) of the construction industry that are economically active in the city of Cuenca, Ecuador, contain several qualitative variables that they face and which are analyzed and studied within this research, such as the amount and frequency of construction projects they have per year, the type of projects they carry out, the management and planning time used during the pre-construction phases including the process and time dedicated to this phase, as well as the profile of the people involved in the organizational work teams, among other variables that can be conceived in different ways in each type of project and in each SME.

We have chosen qualitative research to know variables that could let us understand the reality about constructors who own companies. With this qualitative variable, we can relate and interact variables presented in experiences of other countries, variables presented in Cuenca city with the adoption on BIM processes. By doing this data analysis we could achieve to avoid dead times in work, to improve the productivity and utility together with the optimization of resources used in each architectural project respectively.

1) Case analysis

The experiences of analogous cases that the SMEs have presented in developed countries and in specific countries of South America, which were analyzed in this research shows that the architectural projects carried out are being worked with collaborative methodology online now also they showed up that one of the disadvantages of implementing BIM processes is the high cost of the technology this method implies. However, the cases were BIM methods were applied such as Colombia, show up how the participation of many disciplines and the online collaboration work increases the productivity and the utility in SMEs. Another qualitative variable that was found show up that many SMEs in pioneer countries are also supported by public entities with mandatory rules and regulations from governments.

2) Interviews

The interviews were analyzed since the first moment we had contact with the experts by asking them between open questions all our doubts that we needed to know so we could start linking the qualitative variables from the analysis of similar cases and the qualitative variables that constructors of SMEs face in Cuenca city. By making up an interview with open questions we could analyzed how are the constructions phases managed by experts, and we could understand their opinion about collaborative work and some other important aspects. The interview was done with open questions to analyze all the answers taken from experts and use them as qualitative variables that could let us interrelate them to purpose a method that could be applied within an implementation BIM pilot study in a construction SME.

III. RESULTS

The basic theory about BIM or construction information modeling is that all the relevant data of a project is connected to each other, and at the same time it is stored in a single online system, so that the project can be executed first in a virtual environment [8] and as it advances, time (scheduling) and cost dimensions can be added to the model, thus obtaining an easy cost-time-benefit analysis and with diverse alternatives or options, almost instantly. In addition, in the process of developing the project, more interested parties can be included that can include their commercial or engineering knowledge, facilities, programming and organization achieving better coordination in all phases of the project and even making the future user part of this process. As a result, it is possible to obtain a BIM model represented parametrically with specific and detailed details that content possible data to be analyzed, solved or extracted in a timely manner and that, at the same time, meet the needs of all involved and be used throughout the life cycle of the building. If the BIM is analyzed from a product approach, it can be noted that it is an intelligent representation of the construction or architectural building that is intended to be a repository of information that even the owner or operators will use and will be maintained throughout the life cycle of the building. Through the BIM it is possible to achieve this collaborative process and information exchange between all actors involved due to the collaborative nature of the industry, in the different phases of the project [5].

A. Literary review of similar cases in other countries results

The literary review was carried out by looking for similar cases and scientific contributions that already exist in other countries such as Colombia, Nigeria, Malaysia, etc. In order to study the variables between the barriers, challenges and findings that SMEs have had to face during their implementation experiences of BIM methodologies in architectural projects. Each SME has a different experience because the context of the economic and social environment in which they operate is different in each country respectively (see Fig 2).

SIMILAR CASES OF BIM IN SMES IN OTHER COUNTRIES - QUALITATIVE VARIABLES ANALYSIS

Country Name	Barriers, Challenges, Benefits and Others.
Colombia	SMEs: acronym for small and medium-sized companies, it is a company with distinctive characteristics, and has dimensions with certain occupational and financial limits prefixed by the states or regions. SMEs are agents with specific logics, cultures, interests and an entrepreneurial spirit (Sánchez Ángel & corre basto, 2016). Without a doubt, the biggest driver of BIM implementation in different countries has been the initiatives led by governments, as is the case of the United States of America through the general services administration, on the other hand the UK government. He has led the strategy of the fully collaborative use of BIM in public sector projects worldwide since 2016. It is evident that, by linking the constructor of work in instances prior to the execution of the project, it restores the value of the design phase, since the collaboration and communication of the intervening actors is improved, affecting the quality of the designs and therefore This means reducing the risk of encountering problems derived from constructability, among other problems that affect the productivity of the development process of a construction project. Successfully implementing BIM implies changes in behavior, cultural and technological changes that transform an organization, adapting new processes and implementing new standards (Jones & Laquidara-carr, 2015). The implementation must be led from within: it is difficult to implement the change of processes when it depends entirely on an external consultancy, the process must start from the heart of the organization, leveraged by the expertise of a BIM consultant, the process implementation should be gradual and controlled over time. In addition, the design and construction of projects under integrative delivery methods optimizes project results, since it collaboratively takes advantage of the talent and points of view of all participants (Pons achell, 2014, p. 46). The advantages obtained are the possibility of doing more and spending less, improving communication between professionals and as challenges are the analysis of risks and costs under control linked to the improvement of processes (Sandoval, Bermudez, Torres, 2018).
Perú	The case study analyzed in Peru involves the application of the BIM methodology in the construction of a multifamily housing project where they analyze the percentages of cost optimization by executing a strategy adapted to the project. As the model is being developed, team members are constantly refining and fine-tuning their deliverables, in accordance with project specifications and design changes, to ensure that the model is as accurate as possible. (Guillermo, 2012) Among the challenges is the adequate understanding of the goals, the characteristics of the project and the capabilities of the team members. (Enginnering, April 2010) In addition to the technological innovation of BIM to streamline the workflows of the project design, construction and maintenance process. In this case, the cost of implementing the BIM is S / 14,000.00 and represents 0.08% of the total cost of the work, and with respect to the cost of detected interferences or reprocesses it is 25 times lower. The total budget of the Duplo project is S / 18,044,703.48 and by applying BIM in the project the extra cost of S / 355 948.42 soles was avoided, which represents 30.24% of the total amount of the project's profit. The loss considered in the project profit would drop from 7.50% to 5.23%, 2.27% being the cost of identified interferences (Type et al., 2020).
Italia	This study specifically recommends the need for a review of BIM implementation policy with intensification of BIM education requirements. This can be achieved not only through the introduction of BIM courses but also mainstreaming of BIM within the existing curriculum in the education of designers including architects and civil engineers. There are many examples of such education initiat- ives in countries such as the UK and USA where there are higher levels of adoption (Abdirad & Dossick, 2016). As evident from the findings, the main areas perceived as important to design firms is the need for embedding BIM into education curriculum as well as availability of stan- dard deliverables and components such as BIM objects and libraries (Troiani et al., 2020). Currently, public administrations and governmental bodies in several countries are making efforts to facilitate the implementation of BIM in the construction industry by promoting various initiat- ives, including standards, guidelines, mandates and programmes of BIM implementation (Succar & Kassem, 2015). These market and country-level initiatives have been referred to as macro-level BIM maturity and acknowledged as the precursors to a successful diffusion of BIM in lower tiers such as organisational and individual levels (Succar, 2010).
Malaysia	Implementing BIM should go beyond simply using new software and hardware. In fact, it requires a shift in traditional building delivery processes. Part of this shift is the involvement of all key stakeholders of a building project at the early design stages. This ensures that all parties can provide input from their respective disciplines and experiences to produce a digital model that requires as little change as possible as the project progresses (Liao et al., 2019). Thus, firms and their management should be open to change to effectively implement BIM at the intra-firm level and adapt to industry trends at the inter-firm level. This study revealed that intra- and inter-firm coordination were important factors in BIM implementation. In particular, the inter-firm aspect of BIM implementation has been highlighted by other studies (Brahim et al., 2018; Liao and Teo, 2019) but is not widely researched. In fact, Liao and Teo (2018) found that the current BIM contractual arrangements in Singapore encourage adversarial behavior among stakeholders which represents a hindrance to successful BIM implementation in the country. In Malaysia, Teoh et al. (2018) highlighted the need for a comprehensive contract and legal framework for BIM use in the construction industry. Thus, future research may explore how to harmonize the dynamics of firm-to-firm interaction in the context of BIM implementation. The findings of this study support previous literature which highlights the important role of management in successfully implementing BIM at the organizational level. Results of the ranking analysis are consistent with previous literature which suggests that creating a firm culture where employees and workflows can adapt to new technology should take priority over simply acquiring new software or hardware. This is because the introduction of new technology requires an appropriate framework to support it. Additionally, this study revealed the importance of building effective networks of communication among team members of an AEC firm for successful BIM implementation at the firm level. (Sinoh, Othman, & Ibrahim, 2019)
Nigeria	BIM implementatio and possible ways forward to improving BIM adoption in AEC firms. The study showed the result of factor analysis that grouped the 20 identified barriers into three main factors to include: weak top management support and BIM environment related issues; cost of BIM software and training; and incompatibility, legal, contractual, and culture related issues. Based on these findings, the study recommends as follows: massive awareness of BIM by professional bodies, government agencies, and non- governmental organizations both locally and internationally; professional bodies should continue organizing BIM–related workshops and seminars for their members to further acquire appropriate BIM skills and technical know-how; the cost of BIM software and training of staff should be subsidized by the government and other approved authorities; appropriate government policies and guidelines that support BIM implementation should be in place in developing countries as whole; and BIM concept should be incorporated into academic curricula of architecture, engineering, and construction related disciplines in higher education (Babatunde, 2020).

Fig 2. Similar cases results of BIM adoption in SMEs

B. Important variables according to experts.

During the interviews with experts there were many qualitative variables that were found. The text in boxes represent the expressions that were emphasized by experts.

1) Is there a phase: before, during or after the work, in which it tends to present more complications of time or resources? The qualitative variable that was the most repeated by the experts was the time it takes to carry out the legal approvals in the municipalities during the planification phase. The importance of the resources during the execution process also is highlighted, which if they are not used with proper administration the project is immediately influenced in the time planned within the schedule (see Fig.3).

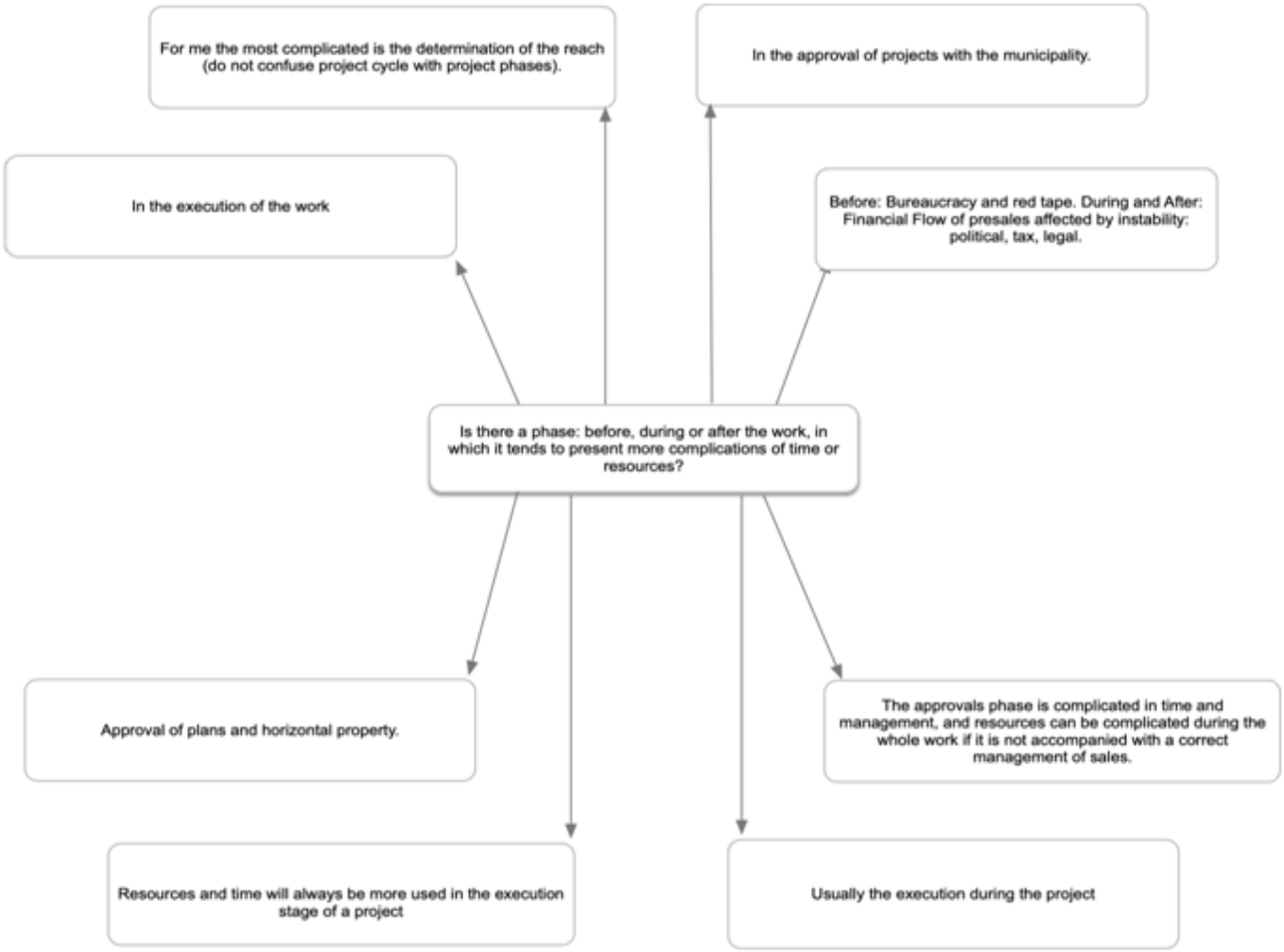

Fig 3. Identified variables in construction phase.

2) How would you define: "Interdisciplinary collaborative work"? Here we wanted to understand what is the conception that builders have about online collaborative work that can be carried out throughout the process of an architectural project, keeping in mind that other disciplines and professions that are specialized in different areas are always required to reach a successful architectural project. A variable that stands out is that the concept of interdisciplinary work with different professions and the essential need for this type of work methodology is quite clear and defined by the experts. All agree that working with professionals specialized in different areas is a methodological strategy to achieve optimal results in time and costs, which allows all those involved in the project to work to achieve the same objective (see Fig 4).

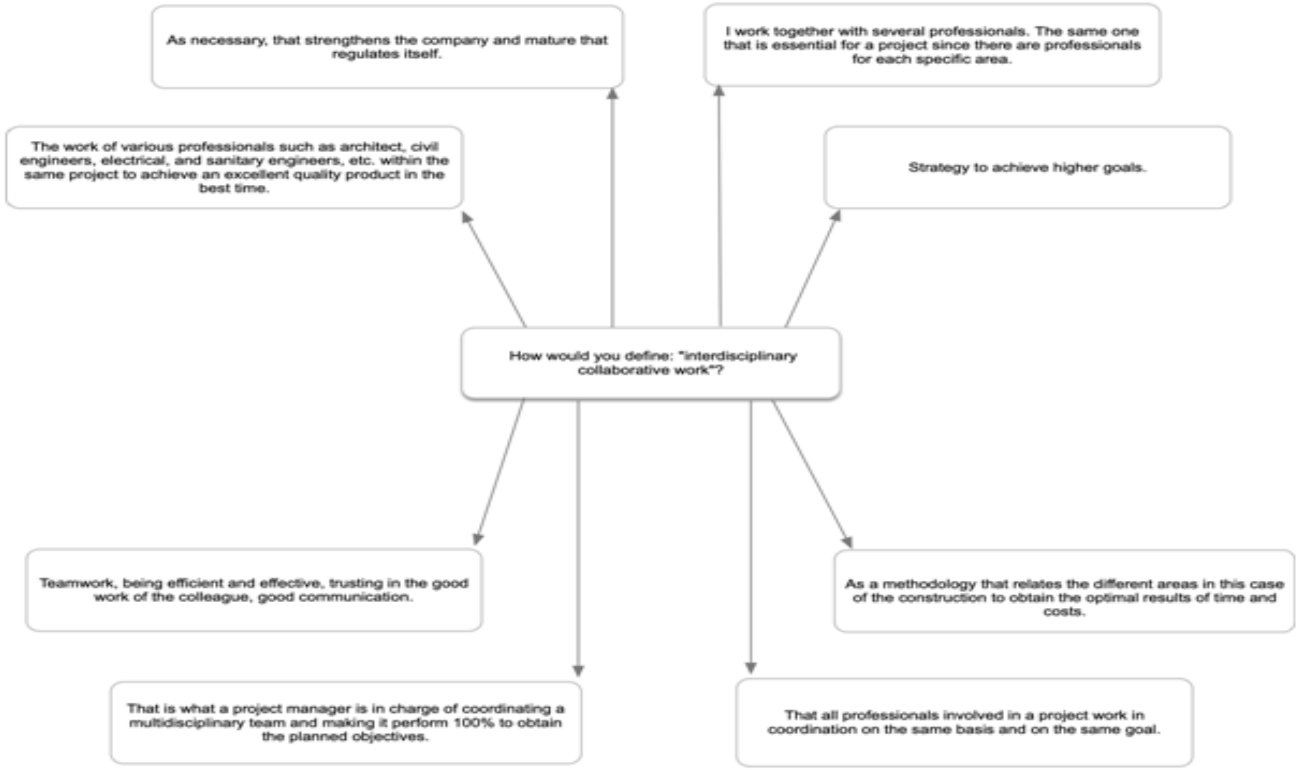

Fig 4. Recognized "Interdisciplinary Collaborative Work" variables.

3) What does it mean to achieve a quality architectural project? Here, we wanted to know what a builder in the study site tries to achieve during an architectural project. The concept of what constructors have to do to get a quality architectural project was studied. Within the analyzed responses, the most notorious variable is the importance of achieving functional and profitable architectural projects with structural quality and adequate construction methods. In addition, the importance of satisfying the functional and aesthetic needs of the user is mentioned. In other words, quality is combined with planned times and costs (see Fig. 5).

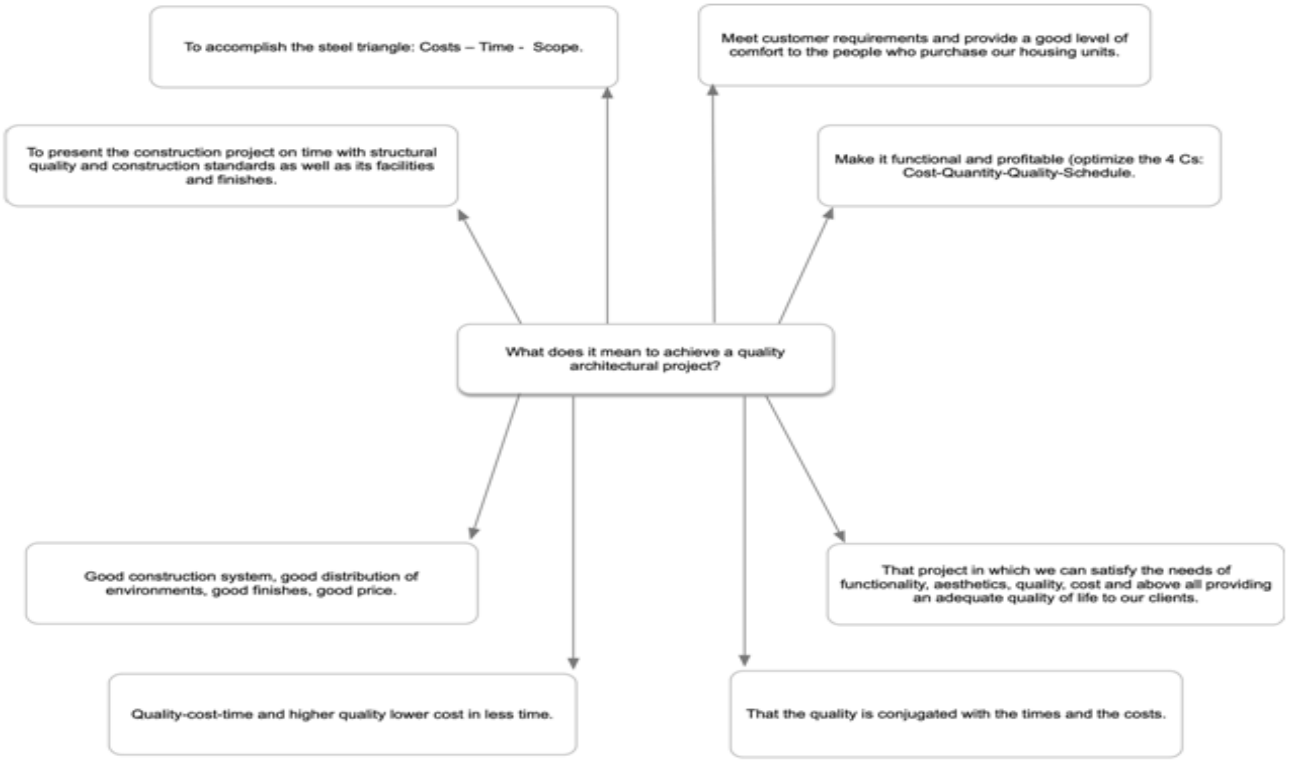

Fig 5. Variables found about quality in architectural projects.

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4) *Do you carry out any kind of follow up, once the work is finished? How? The position of expert builders was also studied when the construction project is finished in the execution stage in order to know if there is any type of maintenance during the life cycle of the architectural project. The resulting variable indicates that once the work is completed, a periodic monitoring is carried out before the final delivery and a closing evaluation. It is necessary to mention that at the moment there is no method that the constructors apply and that includes a follow-up of the architectural entity built throughout its life cycle (see Fig. 6).*

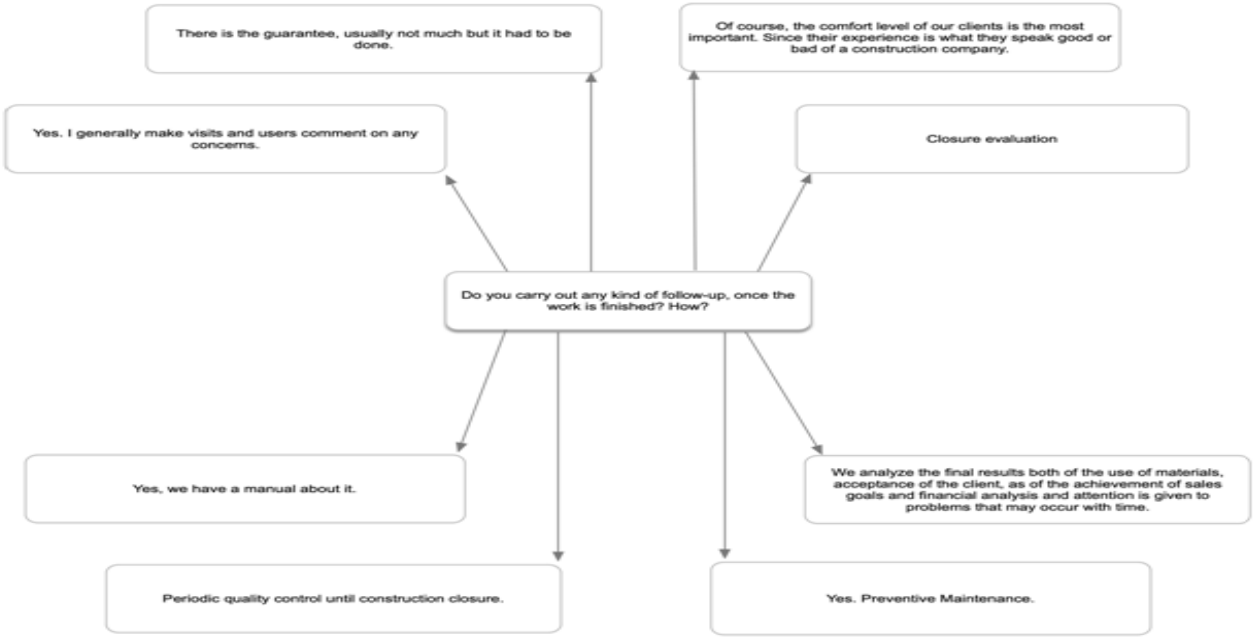

Fig. 6. Variables about the after construction process.

5) *What is the profile of the person in charge of managing a project in your enterprise? Finally this result was one of the most important qualitative variables that allowed us to find and understand the barriers and challenges of implementing BIM strategies and methodologies, was to analyze the profile of the person who is in charge of managing the project within the company. Positively, the variable tells us that the experts interviewed are looking for a person who has a fourth professional level, knowledge of project management and, at the same time has to have constructive knowledge in the engineering area as well (see Fig 7).*

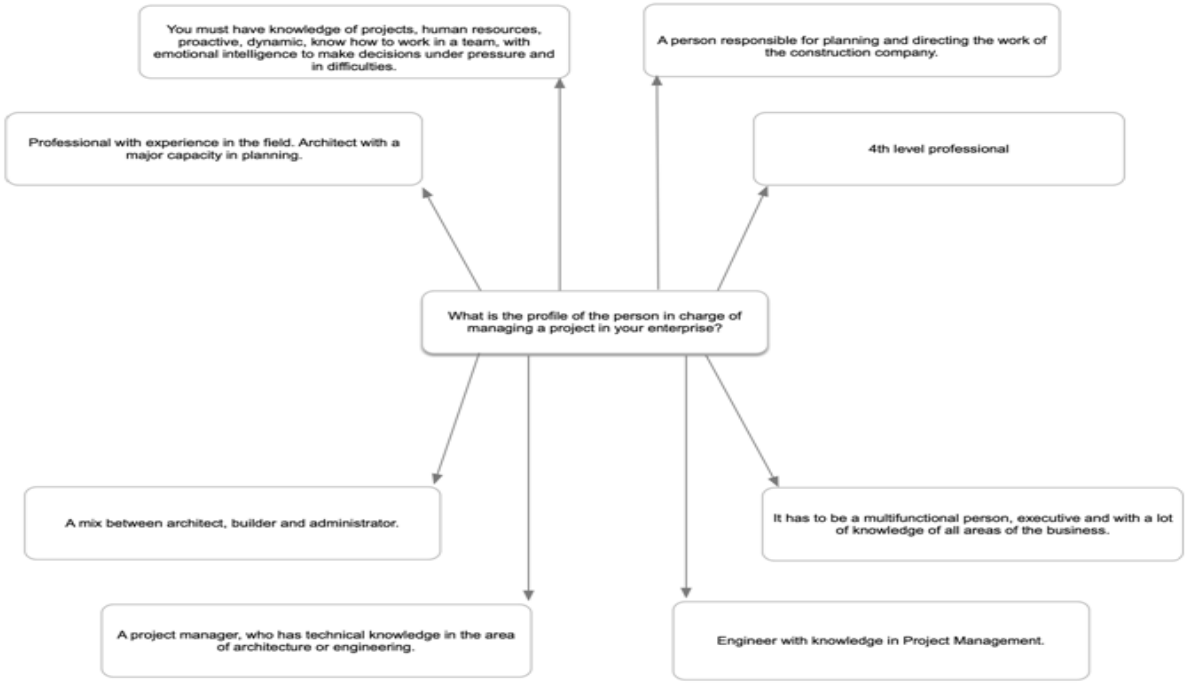

Fig 7. Required profiles to manage the SME architectural projects.

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C. Findings and challenges in the implementation of BIM in construcion SMEs.

There are several cases of SMEs internationally, which have already implemented this type of BIM methodology in their architectural projects, because it is a process that eventually all construction companies must face in order not to be at a competitive disadvantage. The findings found in a case study conducted in Nigeria, reveal that the barriers actually come from a socio-technical context and that SMEs have the will to promote the implementation of BIM, however there is a very traditional way by the technical professionals, which has been used for some years, so you cannot show willingness by the human resource in wanting to change the ways they are accustomed to when facing an architectural project or construction. In addition, barriers were found such as the lack of implementation guidelines and strategies, the high cost of implementation, the lack of financial resources and above all the most influential variable turned out to be the resistance to change and strong will to retain the traditional method [9]. However, the study reveals the urgent need on the part of the SMEs to adopt this process by internal will and to promote it from within the organization, despite the lack of government support. Another interesting case to be mentioned is that of the BIM implementation in the United Kingdom, which has increased significantly in the last decade, particularly since the local government ordered the use of BIM in all public projects by 2016, Since they do not have this collaborative system technology in the projects, they cannot bid on public and private projects, and at the same time they cannot deliver construction projects, which immediately places them at a competitive disadvantage that is aggravated as time goes by [1]. The implementation of BIM requires changing the way of working, so training in the processes is essential to ensure that all employees and stakeholders, have the required level of knowledge, along with the support of senior management to provide the necessary information and ensure communication between stakeholders and involved in it.

D. Methodology and strategies based on qualitative variables of Cuenca City.

Here we present methodological processes and recommendations based on the qualitative analysis of the interviews, and fulfil the necessary indicators for the development of the case study. The proposed processes were made based on the comparative study of the development and interpretation that the projects have had over time and similar experiences of analogous cases in order to achieve as a result: architectural projects managed early and planned correctly to achieve quality results and high standards that in addition will increase and improve productivity and competitiveness in SMEs, which can also be a point of attraction even for foreign investment. The mentioned literary review of construction SMEs was done from countries that are pioneers in the subject so that the barriers and the qualitative variables that they have faced and have assumed as a challenge can be reviewed and related to the SMEs that are in Cuenca. Bearing in mind, the adaptation that is required of it due to the different realities and context of the spaces and environments that are studied, in the same way it is done with analyzed cases of South America.

Fig 8. BIM Strategies and Methodologies to use in Cuenca City.

E. Discussion results

Once the interrelation of the qualitative variables with the interviews to the experts was done with the active builders in the city of Cuenca. The variables analyzed from the similar cases presented by SMEs, let the authors to be possible to carry out and propose methodologies and strategies that can be used and applied in SMEs of the city of Cuenca, as a pilot study in the future. It is necessary to mention that although the variables are different in each place and situation due to the environment in which it is developed, they may be applied and adapted to the construction companies of the city of Cuenca due to the congruences that they present in the environment to be applied.

There are qualitative variables that coincide in certain aspects with other SMEs located in other countries and that were studied in analogical cases, these variables can be adapted and modified per the results obtained in the interviews carried out with experts and based on the scientific contributions collected in the qualitative research process carried out. This qualitative research contributes also to implement a pilot study in a SMEs architectural project in future studies.

IV. CONCLUSIONS

It is necessary to indicate that due to the interrelation of qualitative variables between the analysis of similar cases and between the analysis got from experts in Cuenca City, let us to find out that strategies and recommendations could be applied as a pilot plan at least in the initial phases of an architectural project. Based on the data collection and based on the similar cases review about the implementation of BIM methodologies and strategies in SMEs in developed countries and South America, we can first conclude that constructors seem disposed to implement a BIM methodology in their SMEs at Cuenca city. We could also be looked in the interviews the existing relation of qualitative variables between similar cases and between the variables found in the constructor's interview. Based on it we have showed up some collaborative benefits and productivity improvements that the use of BIM could bring. We have also found out that in Cuenca city already exists a building of housing departments that is in execution, which is being carried out with BIM methodology and it would be interesting to apply in this project a pilot plan relating the qualitative variables founded with the BIM method.

In other countries in South America, such as Peru and Colombia, this type of technology and conception of an architectural project is progressing by leaps and bounds, which represents another important reason why SMEs construction companies must be prepared for this challenge, otherwise they will find themselves at a great uncompetitive advantage. On the other hand, and based on the comparison obtained from similar cases, it is well known that a great challenge to face within this process is the integration and adaptation of professionals to this new type of technology, and to this new way of approaching a architectural project, since today there is still the traditional way of running and managing a project, professionals with various experiences are reluctant to change at some point. However, it is a problem that can be solved within the academy by including this type of collaborative and multidisciplinary concept in the training of high-level professionals. Although the BIM methodology has come to revolutionize the architectural, engineering and construction industry, the benefits to be obtained are evident and noticeable. There are scientific contributions that quantitatively demonstrate in applied studies how the costs percentages could be optimized with the resources as is the study case of: "Management approach to a technical strategy for selection of alternative projects delivery methods and the BIM implementation process in SME organization in the Construction sector of Bogota Dc".

In spite of all the benefits and advantages that we have found, we need to mention an important disadvantage that is the high cost of implementing this new method of working requires if it is applied in an integral form. There are other forms to implement BIM methodologies that will not require a big investment at the initial phase, this could be made in phases and in time lapses during the development of a project, as a pilot plan. The use of a free space online as google drive, could let the stakeholders of a project assume their roles and could let them to collaborative work on line.

Finally, in Cuenca city there is still not a considerable percentage of SMEs that involve BIM processes, it is totally profitable and possible to adapt to them as a pilot plan to start at least. The qualitative variables obtained prove the importance to face architectural projects with collaborative work. People involved in construction have sufficient training and the respective technical knowledge to understand that the incorporation of BIM into a construction is not only at the beginning of the work or in the planning phase. The incorporation of methodologies, strategies and processes BIM imply an integral change in architectural projects and this change has to start even from the respectively governmental entities and authorities. Incorporating BIM strategies within the legal regulations of public and private contracting would allow construction SMEs to be competitive in foreign tenders and in parallel will optimize productivity in resources while they increase earnings. If this happens, all SMEs would advantageously gain competitiveness and prestige in the construction market. Through the methodology generated that was indicated, there are several more areas and fields that can be studied in future, analyzed and expanded in subsequent scientific investigations.

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