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Application of project management tools in engineering services companies: Four case studies

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Abstract. A methodological proposal is designed for the planning of the scope, time and cost that strengthens the management of the projects developed by the services companies of Cúcuta and its metropolitan area. In the first phase, a descriptive study was carried out based on a maturity diagnosis which included the relevant tools to measure the culture in the planning of the scope, time and cost of the projects, which was validated by experts in PMI and applied in thirty companies to the officers who are in charge of the management of the projects. The second stage consisted in the selection of fifteen tools and techniques of the scope, time and cost management of the PMBOK Guide applicable in the methodological proposal according to the diagnosis. Finally, methodological guidelines for project management were designed in four social services companies, technology and computer science and civil constructions in which the tools defined in the proposal were incorporated, which will become guidelines for the execution of the projects guaranteeing the fulfilling of the deliverables, in the estimated time and with the assigned budget.

1. Introduction

The number of projects executed by companies to develop new products, strengthen strategies, develop management plans and reach levels of regional competitiveness is growing every time. In a Latin American context such as Colombia, the challenges of sophistication and innovation for the sustainability of regional competitiveness and productivity indicators are a major challenge. The project culture is not a strong aspect in the analyzed context, given its historical support in the development of wholesale trade, spare parts, clothing and others, induced by its location in border areas. However, the changing context of the neighboring country has led this area of the country to strengthen its planning and management tools for the development of its productivity with certain guarantees of success. Scope, schedule, costs, risks, stakeholders, communications and acquisitions planning tools are key factors in project management; understood according to [1], as a temporary effort to create a unique product, service or result that allows for more efficient management, accountability and control of the mayor in the execution of the baselines of scope, schedule and cost, thus ensuring the successful completion of executed projects.

In this sense, they are adopted for the following theoretical foundations. The concept of integral diagnosis is assumed from [2], where all the factors of the different administrative or production areas that constitute the company must be included in the Situation Analysis. Regarding the diagnosis made in the companies, the OPM3 maturity model was revised and applied [3], which provides metrics that define the current state of the organization, as well as a description of the processes they must follow



to achieve management excellence. Likewise, the tools and processes were oriented taking into account portfolio management [4], in such a way that the projects are aligned with the strategy and objectives of the organization.

For the specific cases of the study, important factors are taken into account for the diagnosis and selection of management tools, according to the mission and operational objectives of the same.

In a technology company, there are several aspects to be taken into account in the strategic analysis process, for which the development of properly planned projects is important; in civil engineering companies, the requirements for construction objects constantly change [5] and the multiple application of project documentation is not possible without its revision and adaptation to modern conditions [6]; likewise, in the era of galloping globalization, there is no way of not talking about risk, which has become an indispensable part of everyday life. Risk is present everywhere, in all areas of life. One of these areas is the construction industry, where risk is the omnipresent element of a big puzzle [7] and in which it is recommended to carry out an analysis that includes the identification of risks, including the identification of risks, the evaluation of their probability and damage [8] and that allow decisions to be taken adhering to previously established principles [9] since the absence of guidelines can cause chaos and eventually lead to erroneous solutions [10]. In social service companies, there is an urgent need to manage multidisciplinary projects for the social development of families, which means the development of productive, educational, health intervention, recreation, or family welfare projects. It is important to emphasize that in the development of the methodology the tools and techniques of the PMBOK were applied in the elaboration of the templates and procedures used in the planning of the scope, time and cost of the projects for the service companies, which would be incorporated later in the four case studies developed.

2. Materials and methods

A diagnosis of maturity was made with a descriptive study through a structured survey with 10 closed questions described in Table 1, according to the operation of variables of the stakeholder, scope, time and cost management used during the planning process of the project according to [11], which can be seen in Table 1. A likert scale was applied with five response options, never (0), in some cases (1), in most cases (2), always (3). The instrument was validated by four experts in project management and the survey was completed by officers in charge of project management of companies that offer Government Services, University Extension, Construction, Cooperatives, Consulting Companies, Telecommunications, among others, located in the city of Cúcuta and its metropolitan area.

Table 1. Diagnostic questionnaire of maturity.

Aspect to evaluate	Compliance			
	0	1	2	3
Is the project formulation taking into account the participation of the different stakeholders?				
For each project formulated is a record of the stakeholders with the degree of participation and importance?				
Is a record of previous projects maintained and lessons learned?				
Are the high-level risks established when the project is formulated?				
Are the projects formalized through the Constitution Act?				
Are the acceptance criteria established for each deliverables of the project?				
Do the deliverables defined within the scope of the project decompose hierarchically?				
For each activity of the project is the duration and resources of it established?				
For each activity of the project is assigned the responsible for it?				
Is the budget drawn up based on the estimation of the resources of the activities?				

To develop the operationalization of variables, the areas of stakeholders, sope, time and cost of the projects were taken into account, as shown in Table 2.

Table 2. Operationalization of variables.

Variable	Component	Description description	Indicator
Stakeholders	Identification of stakeholders	The group of people with an interest in the project identify themselves and become involved in the planning process.	Involvement of stakeholders in the collection of requirements.
Scope	Acceptance criteria; work breakdown structure (WBS)	Allows to make an adequate identification of the requirements and to elaborate the WBS.	Collection of information related to requirements, disaggregated task structure (WBS), lessons learned and monitoring of activities.
Time	Sequencing of activities and duration responsible by activity	Time planning allows for adequate sequencing and duration of activities, allocation of start and end dates for each activity and establishment of the person responsible.	Information will be collected regarding the procedures used to sequence and estimate the duration of activities.
Cost	Type and quantity of materials, cost estimates by activity; budget and cost performance	Cost planning allows for proper allocation of the type and quantity of materials, cost identification, and budgeting of cost performance.	Collection of information related to the type and quantity of materials; identification of costs by activity; Budget and monitoring.

In the calculation of the sample, a population of 350 service companies was taken as reference, from which a sample of 30 companies was obtained, calculated with a confidence level of 95% and a margin of error of 5%. The measurement instrument was a survey of 10 closed questions, for which the variables of operationalization: stakeholders, scope, time, cost was identified and analyzed and the Likert scale was applied with five response options, an instrument validated by four experts in Project Management.

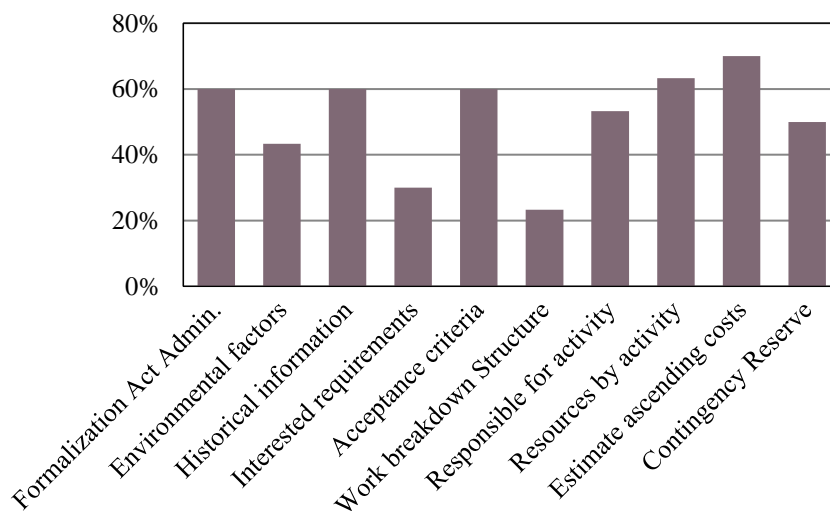


Figure 1. Diagnostic conclusions of maturity.

Subsequently, the information of the officers in charge of the management of the projects in companies of the Services sector at the level of Cúcuta and its metropolitan area was recorded. The tabulation and analysis of the data yielded the conclusions visualized in Figure 1.

3. Results and discussion

Once the diagnosis was completed, the tools and techniques feasible to incorporate into the methodological proposal for each of the processes of the scope, schedule and cost management in the planning process of the service companies were applied in four organizations that participated in the study and which are described in the cases listed below.

3.1. Case 1: Services/engineering

Gnosoft Company develops technological solutions for the planning of business resources, such as academic software and hospital audits offered to schools, clinics and hospitals in the city of Cúcuta. In the project, PMI planning tools were developed, which were applied to the marketing department in the development of a plan that would increase the level of productivity, strengthen the skills of the vendors, improve the productive chain and that it would later allow the implementation of an information system for decision making.

Table 3. Deliverable per business case.

Deliveries	Management area	Utility	Case			
			1	2	3	4
Project Charter	Integration	Formalizes the project; provides a high-level description of the project and the characteristics of the product.	X	X		X
Register of stakeholders	Sakeholders	Identifies the main stakeholders of the project.		X		X
Power/Interest rating model	Stakeholders	Allows to establish the power and interest of the different stakeholders involved in the project.	X	X	X	X
Scope management plan	Scope	It facilitates the control of the scope of the project.	X	X		X
Requirements management plan	Scope	Define the requirements.		X		X
Work breakdown structure (WBS)	Scope	View deliverables and work packages.				X
Dictionary of WBS	Scope	Provides detailed information about the deliverables.				X
Requirements traceability matrix	Scope	Facilitates the control of the fulfillment of the requirements of the deliverables.		X		
Schedule management plan	Schedule	Follow-up of the fulfilment of the activities in the planned dates.	X	X		X
Project Schedule	Schedule	It updates the start and end dates of the activities.			X	X
Cost management plan	Costs	Follow-up of the executed expenses in the budgeted items.	X	X		X
Project budget	Cost	View the planned expenses per item.	X		X	X

3.2. Case 3: Services/civil works

Construinterventores NJ SAS, develops interventory projects in Civil Engineering and in the project a methodological guide was designed to standardize the supervision and control of civil projects that will allow the control of the works developed by the company to be carried out. According to [12], the engineering and building projects, by their very definition, are unique in their conception and subsequent materialization in an environment with conditions that may be similar to others but are never the same.

3.3. Case 4: Services/cash compensation

La Caja de Compensación Familiar de Norte de Santander COMFANORTE, offers welfare services to its members and most of the projects it has developed have not been approved due to the lack of methodologies and tools for planning them, so the authors developed a methodological guide to standardize the planning of stakeholders, scope, time and cost of social projects.

Table 3 describes the usefulness of deliverables submitted by each of the companies defined in cases, as well as the management area to which they belong.

As a contribution to the companies benefited they were advised in the construction of the methodological guides in which the tools used in the study were used for the planning of the scope, timetable and cost of the projects, which are observed in the Table 4.

Table 4. Tools of planning of project scope, time and cost.

Tool	Case 1	Case 2	Case 3	Case 4
Interview		X		X
Questionnaires and/or surveys		X	X	
Observation		X	X	
Document analysis		X	X	X
Trial of experts	X	X	X	X
Facilitation techniques	X	X		
Decomposition		X	X	X
Precedence diagramming method			X	X
Ascending estimation		X		X
Estimation by three values (PERT)	X	X	X	X
Critical route method	X	X	X	X
Project management software	X	X	X	X
Vendor offer analysis	X	X	X	X
Reserve analysis		X	X	

4. Conclusions

In the development of the project, descriptive research was used, whose purpose was to obtain information related to the maturity in the planning of the projects developed by the selected companies in the study. In the first phase of the project a diagnosis was developed in which it was concluded that the companies are at a low level with respect to the identification requirements, breakdown of activities and elaboration of the broken down structure of work; likewise, few companies reserve contingency and management in the budget, which causes delays in the delivery of products, budgets exceeded and interested dissatisfied with the deliverables. Another important finding has to do with the average level obtained in the estimation of resources of the activities and in the quantification of the response plans.

In the second phase of the project the tools were selected that will facilitate the design of the templates to be used by the project managers in the planning of the scope, time and cost, among which the application of questionnaires excels, Interviews and context diagrams for the compilation of requirements; the application of the technique of estimation by three values for the calculation of the duration and cost of the activities, the use of the ascending estimate for the elaboration of the cost of the project deliverables and the allocation of contingency and management reserve.

In the third phase, a methodology was proposed for planning the scope, time and cost of projects under the PMI standards, which has become a valuable tool for the project managers of service companies efficiently manage projects and finalize them over time and with the budget established for which a series of tools and techniques were included, among which stand out, the interviews, application of questionnaires, observation of processes, analysis of documents used in the compilation of requirements; expert judgment in the definition of scope, activities, preparation of the schedule and budget, decomposition of work packages and use of expert judgment in the preparation of the WBS, ascending estimation, PERT estimation, critical route method, compression of the chronogram, as tools to plan the time of the activities and the methods of ascending estimation, by three values, reervas analysis and expert judgment in the planning of the costs of the project, which facilitated the elaboration of the methodological guides for the development of projects in the companies World Systems Projects, GNOSOFT, Caja de Compensación Familiar de Norte de Santander and Construinterventores NJ SAS.

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