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PMBOK AND VALUE ANALYSIS IN CONSTRUCTION

Ricardo Cristóbal Vivanco León
Vivanco Construcciones (Ecuador)
rvivancoleon69@gmail.com · https://orcid.org/0000-0002-9350-5328

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

Keywords: PMBOK, Value, Cost, Profit.

EL PMBOK Y EL ANÁLISIS DE VALOR EN LA CONSTRUCCIÓN

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

Palabras clave: PMBOK, Valor, Costos, Beneficio.

Introduction

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

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

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

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

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

Table 1

Costs tariffs Empresa Pública Metropolitana de Gestión Integral de Residuos Sólidos

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

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

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

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

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

Method

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

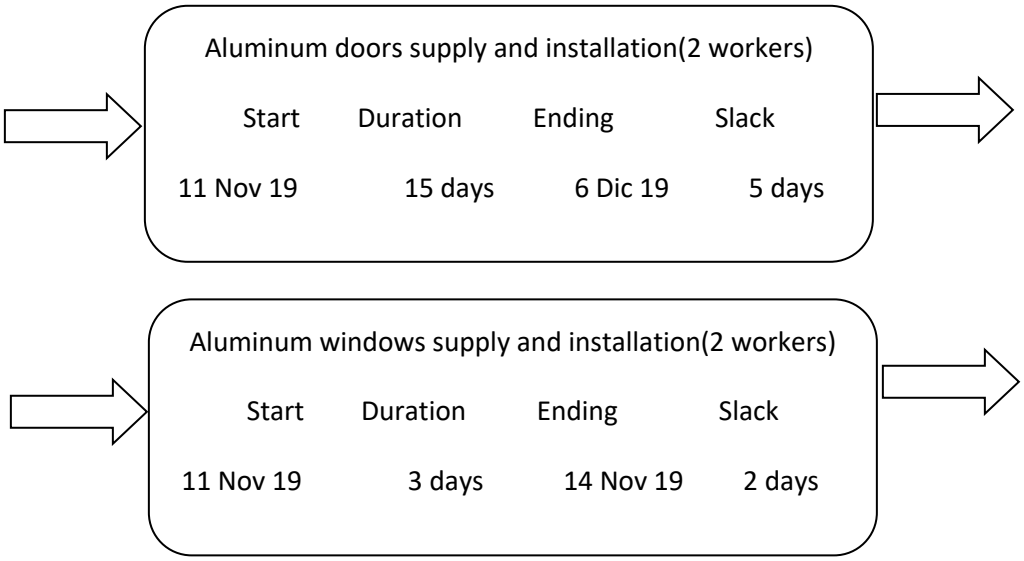

Figure 1. Initial slack analysis in schedules.

Note: Source: Author's creation (2020)

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

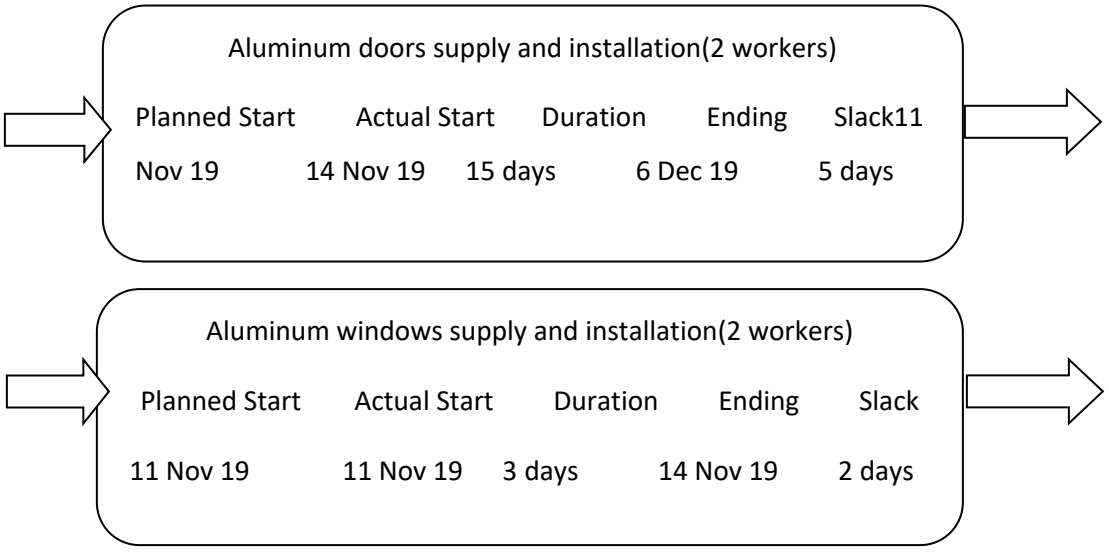

Figure 2. Value analysis in schedules.

Note: Source: Author's creation (2020)

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

Results

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

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

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

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

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

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

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

Discussion and conclusions

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

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

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

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

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

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