Cost management in a building renovation project in the city of Hartford-CT, USA.

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Abstract

Cost management is a fundamental step in any project, regardless of size and characteristics, as it is essential to balance finances and maintain the quality of services. It is important to develop good cost management through a systematic and judicious approach, as the market has become increasingly competitive, especially with regard to the construction sector. In this way, seeking to align the client's needs with the use of project management methodology, as well as the use of its tools within the scope of renovation, this work aims to plan and control costs throughout the project's renovation process, the in order to prevent failures during the stages that could affect the defined deadlines and planned costs.
Keywords: WBS; Parametric; Bottom-Up; EVA; TCPI.

1 Introduction

According to data released by “Mordor Intelligence” [MI] (2023), the homebuilding sector has been the driving force in the US economic recovery from the COVID-19 crisis since the third quarter of 2020, generating double-digit growth rates and making significant contributions to the economy and the overall recovery of the construction industry. Limited mortgage rates, robust demand for larger living spaces, and a low inventory of homes on the market continue to drive the sector. Home renovation, in addition to new construction, is a significant aspect of residential construction. According to the author, by 2023, the annual value of residential building upgrades in the United States is expected to exceed $205 billion. More than 330,000 new rental units are scheduled to be delivered nationwide. Eight metros are expected to set five-year highs in new apartment deliveries, despite the obstacles of the pandemic. Considering the growth forecasts in the residential sector until the end of 2023 and the great competitiveness in the construction industry, it is important to find new ways to optimize routines and comply with plans. It is not uncommon to face problems with delays in deliveries, which eventually lead to increased expenses that can even compromise the quality of the project. To prevent this from happening, good cost management in the construction is essential. And to help in this process, it is necessary to rely on technology and process tools to

ensure better cost control in projects, applying solutions that enhance the organization of activities and the company's results (hinc.com.br, April 13, 2023)

According to the “Project Management Body of Knowledge [PMBOK]” (“Project Management Institute [PMI]”, 2017), project cost management includes the processes involved in planning, estimating, budgeting and cost control, so that the project can be completed within the approved budget.

Thus, the final objective of this work is based on planning and controlling labor and material costs, using cost management tools as a method, in order to avoid internal and external interference that could compromise planned costs, deadlines and the 30% gross profit expected by the end of the work.

2 Methodology

The reason for research can be intellectual or practical. In the intellectual order, the researcher satisfies his or her own desires by studying something. In the practical order, the researcher's work is more active and efficiency and effectiveness gain more prominence (Lozada and Nunes, 2018). The concern with discovering and, therefore, explaining nature dates back to the beginning of humanity, when the two main questions referred to the forces of nature, at whose mercy men lived, and death (Marconi and Lakatos, 2003). As for the method, it can be explained by the sequencing of operations carried out with the aim of achieving a certain result, being a systematic and orderly way of thinking and investigating, forming a set of procedures that allow reaching scientific truth. Thus, the scientific method leads the study to meet its objectives, facilitating the presentation of the scientific problem that the research intends to investigate, as well as the proof (or refutation) of the hypotheses proposed by it (Lozada and Nunes, 2018). Regarding the method, this research is classified as being of an applied nature. Applied research, according to the description by Lozada and Nunes (2018), is carried out with the aim of solving concrete and immediate problems or needs. In the applied research approach, there are cases in which the research problem is part of the researcher's professional context. In many cases, it is suggested by the institution itself to which the researcher belongs. Regarding the objective, we can classify it as descriptive research. The objective of descriptive research is to group and analyze various pieces of information about the subject being studied. Its main difference in relation to exploratory research is that the subject is already known. Thus, the researcher can provide new insights into a reality that has already been mapped (Lozada and Nunes 2018).

2.1 Case Study

The object of study presented in this paper corresponds to the renovation project of a building located in the city of Hartford, State of Connecticut. The contracted company is a company specialized in painting and also an investor in the civil construction sector, in the State of “Connecticut”, United States.

The reason why this project was requested by the client was due to a fire that occurred in February 2023, where the entire internal structural part, on both sides of the building, was destroyed. One part was destroyed by the fire and the other part, in turn, was affected by the water used by the firefighters in an attempt to contain the flames. This is a very old building, built in 1910. The building is divided into 3 floors, with two apartments per floor. The works started in Jul. 2023 and the expected delivery date would be Nov. 2023. It is emphasized that the data obtained and analyzed during the development of the research were updated until the date of Sep. 9, 2023, when the work already indicated progress of 58.00% of the work already carried out.

2.2 Data collection and interpretation

In order to collect the data, the contracted company initially provided all documents containing the client's descriptions and requirements regarding the project, as well as all the stages to be completed and a list of materials. A report containing the results of the inspection carried out on the building by the engineer and the project's financier was also made available. In addition to these documents, full access was also obtained to the records of similar projects carried out by the company, which were used as a basis for comparing labor and material prices.

The project required the renovation of a 3-story building with 2 apartment units per floor. The 3 units on the right side were required to be completely restored, including the installation of a new drywall skeleton. On the left side, the entire wall, including the ceiling, was restored. In addition to the replacement of all the items that make up the interior finish of the 6 apartment units. Finally, a contract with a budget pre-approved by the contractor in the amount of US$150,000.00. To begin the project, as stipulated in the contract, an advance payment of $50,000 was made. The remaining amount was paid as the other phases of the project progressed. The deadline required for delivery of all units was 5 months, starting from the signing of the contract.

2.3 The planning

The planning phase was the first and main stage of this project. According to the PMI definition (2014), the planning process aims to establish policies, procedures and documentation for planning, management, expenditure and cost control of the project. In order to improve data processing methods and the cost management plan, the planning was divided into two phases, as shown in Figure 1. In the first phase, a meeting was held with stakeholders, where all project needs were discussed through a "Brainstorming". The Brainstorming, which emerged in the 1930s, was developed through the "5W2H" action plan. Serving as a basis for planning, this tool can be applied in several areas of knowledge. It is a method that basically consists of asking questions in order to obtain the essential information that will support planning in general. The 5W2H action plan, is originates from the English terms "What, Who, Why, Where, When, How, How much/How many" (Krieger, 2018).

In the second phase of planning, the Project Charter [TAP], the scope statement, the Work Breakdown Structure [WBS] and the activity schedule were created.

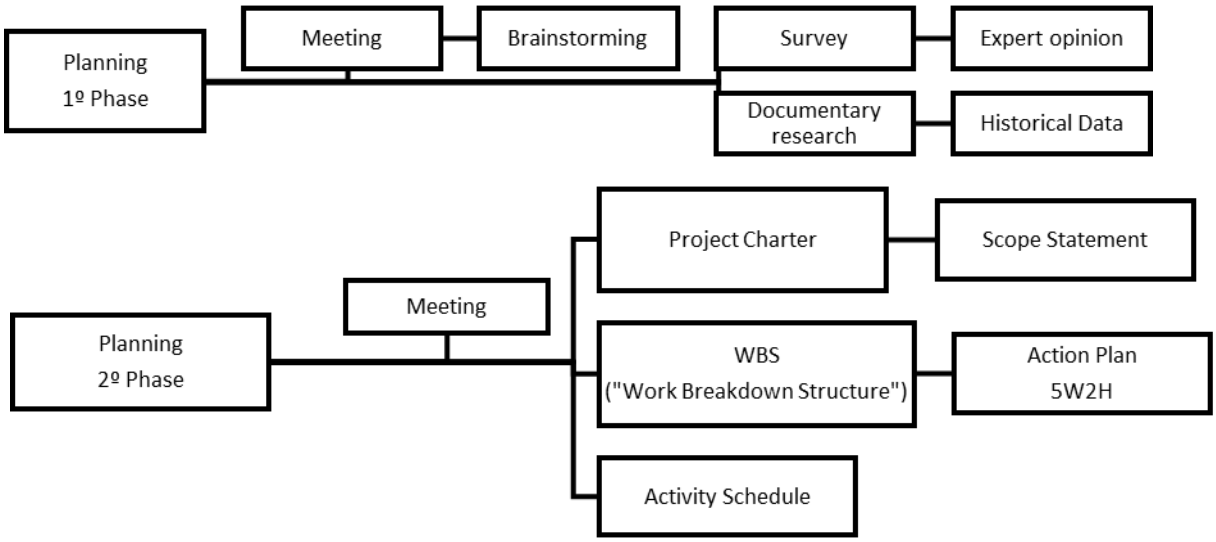

Figure 1. Distribution of activities in the 1st and second phase of planning
Source. Original research results

2.4 Resource Estimation

Resource estimation is the process of evaluating the number of work periods likely to be required to complete identified activities. Activity durations are often difficult to estimate due to the various factors that can influence them, such as resource skill and productivity (Cavalcanti and Silveira 2016). Two estimation models were defined for this project.

Parametric estimation and bottom-up estimation, to determine the costs of individual activities, as described in the WBS and activity schedule.

2.4.1 Parametric Estimation

According to Cavalcanti and Silveira (2016), parametric estimation uses a mathematical model that relates duration to the amount of resources, resource skills, activity complexity, among others. The simplest parametric estimation of duration considers the effort required and divides it by the estimated productivity of the resource. Productivity is a parameter whose estimation depends on the specific area of application. In the case of the apartment painting example, a painter's productivity can be estimated relatively easily by consulting specialized publications in the area of civil engineering. These publications carry out statistical studies that allow for the estimation of standardized work in engineering projects with a certain degree of accuracy. To estimate the duration of activities in the parametric model, highly relevant historical data were used, as well as information on the items described in the service provision contract, in addition to the sum of all project activities, where the labor costs for drywall installations, painting and vinyl flooring, bathroom ceramics and kitchen tiles were estimated. It was concluded, through calculations of the activities described in the WBS, that the cost of the activities would be $48,402.00, as shown in Figure 2.

Resource	Units (m^2)	Labor Cost ($)	Total Labor Cost ($)	Material Cost ($)	Total Cost ($)
Drywall Installation	1,530	5.23	8,000.00	7,500.00	15,500.00
Painting	557	28.72	16,000.00	4,000.00	20,000.00
Vinyl Flooring	240	18.33	4,400.00	6,000.00	10,400.00
Bathroom Tile Flooring	36	17.00	612.00	690.00	1,302.00
Tile Installation	6	150.00	900.00	300.00	1,200.00
Total			**29,912.00**	**18,490.00**	**48,402.00**

Figure 2. Calculations of estimates in the parametric model
Source. Original research results

2.4.2 Bottom-up Estimating

The concept of bottom-up estimating in the view of PMI (2014), is a method of estimating a work item. The cost of individual activities or work packages is estimated to the highest level of detail specified. The detailed cost is then summarized or rolled up to higher levels for use in subsequent reporting and tracking. The cost and accuracy of bottom-up cost estimating are generally influenced by the size or complexity of the individual activity or work package. The "bottom-up" estimation model was applied to the individual work packages related to carpentry, bathroom renovations, carpet installation, kitchen cabinet installation, and the construction of the new access stairs. The choice of this estimation model is related to the number of individual activities in the project. After summing all the activities included in the work packages, it was concluded that the costs for this phase of the project would amount to $54,085.00, as shown in Figure 3.

Resource	Units	Labor Cost ($)	Total Labor Cost ($)	Material Cost ($)	Total Cost ($)
Medicine Cabinet Carpentry	6 pcs	42.50	255.00	460.00	715.00
Closet Carpentry	6 pcs	42.50	255.00	460.00	715.00
Installation of Beadboard Panels	6 pcs	570.00	3,420.00	2,680.00	6,100.00
Assembly of Vanities and Sink	6 pcs	97.50	585.00	900.00	1,485.00
Assembly of Showers and Components	6 sets	40.00	240.00	800.00	1,040.00
Installation of Carpets	6 sets	160.00	960.00	6,000.00	6,960.00
Plywood for Vinyl Flooring	68 units	20.00	1,360.00	1,640.00	3,000.00
Installation of Countertops, Sinks, and Faucets	6 sets	70.00	420.00	2,820.00	3,240.00
Installation of Kitchen Cabinets	6 sets	196.00	1,180.00	11,980.00	13,160.00
Project Management	300 hours	22.00	6,380.00	720.00	7,100.00
Total			**19,765.00**	**34,320.00**	**54,085.00**

Figure 3. Calculations of estimates in the bottom-up model
Source. Original research results

2.5 Cost Aggregation

This phase of the budget primarily aims, according to PMI (2017), to aggregate the estimated costs of activities and work packages to develop the cost baseline. The cost baseline

for this project results from the aggregation of cost estimates, amounting to $102,487.00, plus a contingency reserve of $5,200.00. The contingency reserve is defined as the time or money allocated in the schedule or cost baseline for known risks, with active response strategies (PMI, 2021).

This reserve was added to the work packages corresponding to drywall and carpentry services, taking into account forecasts of price increases for lumber due to ongoing wildfires in Canada. Regarding the work package related to painting, the reserve was applied considering that, at any stage of internal or external painting, the need for rework may arise due to various factors.

Therefore, it is concluded that the cost baseline for this project is $107,687.00.

2.6 Final Budget

The total budget of a project is determined by the sum of the cost baseline and the management reserve. The management reserve, in turn, is a portion of the project budget or schedule maintained outside the Performance Measurement Baseline (PMB) for the purpose of controlling what is reserved for unforeseen work within the project scope (PMI, 2021). In previous renovation projects of different enterprises, a document analysis showed a variation of 5% to 10% in the budget. Thus, a management reserve of 10% was established (not available to the project manager).

2.7 Cost Control

It is natural that in many projects, achieving the goal of staying within the planned deadlines and costs may not be possible. This failure is often related to ineffective control of the entire project. Incorrect estimates, deadlines that are incompatible with the volume of work, sudden changes in scope, and lack of monitoring are the main causes. Cavalcanti and Silveira (2016) describe the control phase as one of the key factors in evaluating project success, as it enables the process of monitoring project expenditures to update and control the budget through preventive and corrective actions.

For this phase of the project, the use of Earned Value Analysis (EVA) and the Performance Index for Completion (PIC) was determined.

2.8 Earned Value Analysis

Earned Value Analysis (EVA) tools are very useful for integrated monitoring of project scope, cost, and schedule. According to Cavalcanti and Silveira (2016), it is one of the main control tools as it allows the project manager to have a comprehensive view of the project in terms of cost, scope, and time. Its principles can be applied to any project and at any level (activity and work package). For this specific project, such tools were used to find the earned value for each activity and to compare whether the project is negative, positive, or within budget, as can be seen in Figure 4 and Figure 5, where the results obtained through calculations can be analyzed. According to PMI (2017), this calculation can be performed simply, as shown in Formula (1), where Earned Value (EV) represents the planned value to be delivered by the time of analysis. Its result is the multiplication of the percentage of completion of each task by its planned value. Meanwhile, Actual Cost (AC) represents the cost incurred up to the time of analysis.

$$EVA = EV - AC \quad (1)$$

Activity	PV (Planned Value)	Completed (%)	EV (Earned Value)	AC (Actual Cost)	EVA (Earned Value Analysis)
Project Management	$7,100.00	93	$6,603.00	$6,938.00	$335.00
Drywall Installation	$17,500.00	100	$17,500.00	$17,317.00	$183.00
Painting	$22,000.00	85	$18,700.00	$22,065.00	-$3,365.00
Vinyl Floor Covering	$10,400.00	100	$10,400.00	$9,480.00	$920.00
Bathroom Floor Covering	$1,302.00	100	$1,302.00	$1,302.00	$0
Tile Covering	$1,200.00	100	$1,200.00	$1,180.00	$20.00
Stair Carpentry	$8,500.00	100	$8,500.00	$9,000.00	-$500.00
Door Carpentry	$3,270.00	100	$3,270.00	$3,770.00	-$500.00
Medicine Cabinet Carpentry	$715.00	100	$715.00	$915.00	-$200.00
Closet Carpentry	$715.00	100	$715.00	$915.00	-$200.00
Installation of Beadboard Panels	$6,100.00	80	$4,880.00	$5,080.00	-$200.00
Assembly of Vanities and Sink	$1,485.00	100	$1,485.00	$1,485.00	$0
Assembly of Showers and Components	$1,040.00	100	$1,040.00	$1,040.00	$0
Carpet Installation	$6,960.00	100	$6,960.00	$6,960.00	$0
Vinyl Floor Plywood	$3,000.00	100	$3,000.00	$3,000.00	$0
Installation of Countertops, Sinks, and Faucets	$3,240.00	100	$3,240.00	$3,239.00	$1
Installation of Kitchen Cabinets	$13,160.00	100	$13,160.00	$13,160.00	$200.00
Total	**$107,687.00**	**92**	**$102,870.00**	**$106,846.00**	**-$3,976.00**

Figure 4. Results of the Earned Value Analysis
Source. Original research results

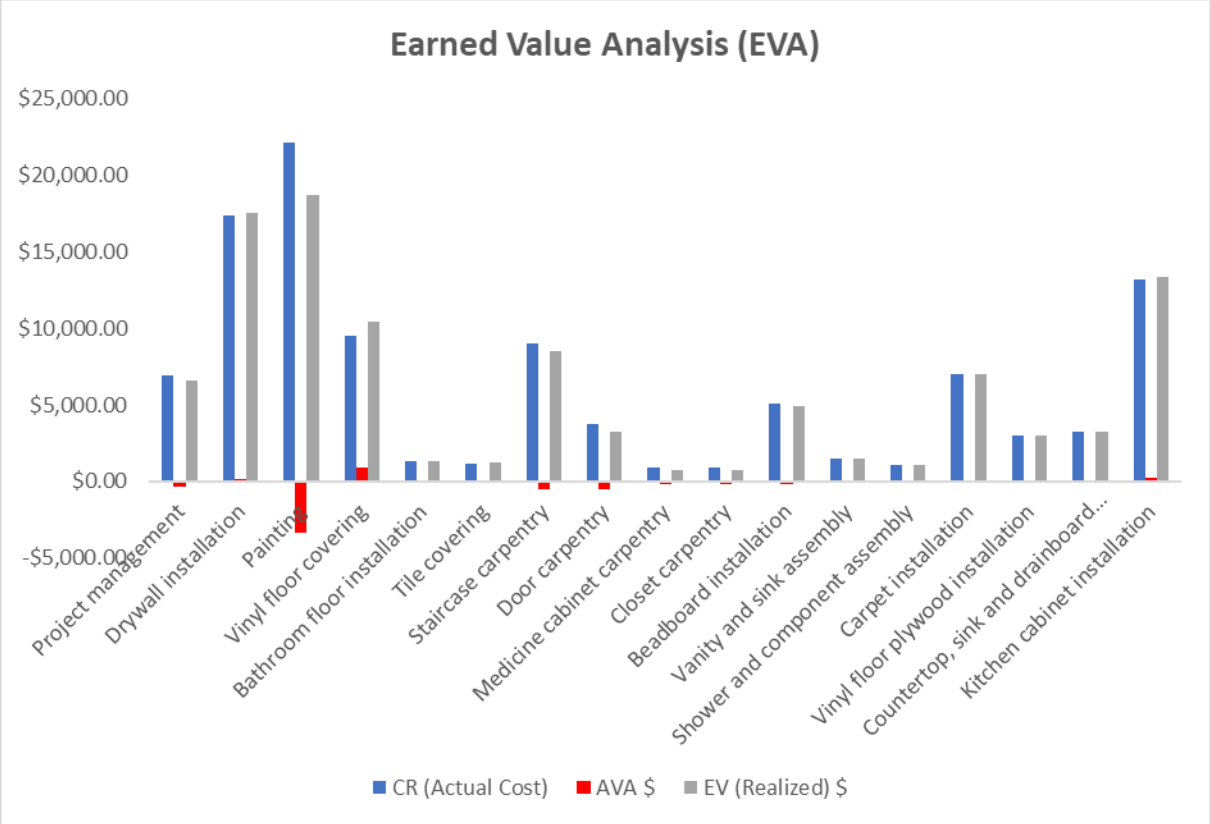

Figure 5. Earned Value Analysis
Source: Original Survey Results

It can be concluded from the graphical analysis that the activities related to carpentry, painting, panel installation, and management show a negative EVA, meaning the project spent more on these activities than initially budgeted, exceeding the budget. In contrast, the other activities display a positive or zero EVA, indicating that the project spent less or exactly what was planned for these activities, remaining below or within the budget.

2.9 Performance Index for Completion (PIC)

According to Barbosa et al. (2019), the PIC is the calculated projection of the cost performance index to be achieved for the remaining work on the project, ensuring that the budget at completion (BAC) or the estimate at completion (EAC or new BAC) is met. Its purpose is to determine the efficiency required to utilize the remaining resources to finish the project on time and to achieve the original budget. This index can be calculated using the values according to the formula (2), where BAC corresponds to the original budget, VA is the earned value, and CR is the actual cost.

$$PIC = \frac{BAC - CR}{BAC - VA} \quad (2)$$

Considering that for this project the original budget (BAC) is $150,000.00, the earned value (EV) is $106,656.00, and the actual cost (AC) is $110,570.00, we have:

$$PIC = \frac{(150.000{,}00 - 102.870{,}00)}{150.000{,}00 - 106.846{,}00}$$

$$PIC = \frac{47.130{,}00}{43.154{,}00}$$

PIC= 1.09

It can be concluded that the project is ahead of schedule and will finish within the expected budget.

2.10 Profit

The results regarding the expected profit at the end of the project can be seen in Figure 6 and Figure 7, where a gross profit of $43,154.00 was achieved, representing 28.77% of the total value. The net profit of this project is the deduction of 15.30% from the total gross profit, which relates to labor taxes. This deduction is defined based on federal state laws. As defined, an LLC does not pay taxes on business revenue and does not need to file a return with the IRS. Instead, the owner, being the sole member, pays taxes on the LLC's profits. In addition to federal income tax, the owner is responsible for paying federal self-employment taxes, which amount to 15.30% of the total (Small Business Development Center [SBDC], 2022).

Thus, although the profit was below expectations, which aimed for 30% of the gross profit, this result is considered satisfactory given that all labor for the project was subcontracted. Additionally, the company is managing several projects simultaneously, including larger projects than the one presented in this case study, which allows for better financial balance with greater earnings.

Activity	Original Budget	Actual Cost (CR) $	Final Profit
Project Management	7,100.00	6,938.00	162.00
Drywall Installation	23,620.00	17,317.00	7,683.00
Painting	30,000.00	22,065.00	7,935.00
Vinyl Floor Covering	10,800.00	9,480.00	1,320.00
Bathroom Floor Covering	2,000.00	1,302.00	698.00
Tile Installation	1,180.00	1,180.00	0.00
Stair Carpentry	12,800.00	9,000.00	3,800.00
Door Carpentry	6,200.00	3,370.00	3,430.00
Medicine Cabinet Carpentry	2,700.00	915.00	1,385.00
Closet Carpentry	2,000.00	915.00	1,085.00
Beadboard Panel Installation	16,000.00	5,080.00	10,920.00
Vanity and Sink Assembly	5,000.00	1,485.00	3,515.00
Shower and Components Assembly	2,000.00	1,040.00	960.00
Carpet Installation	7,300.00	6,960.00	340.00
Vinyl Floor Plywood	3,000.00	3,000.00	0.00
Countertop, Sink, and Faucet Installation	3,800.00	3,239.00	561.00
Kitchen Cabinet Installation	14,200.00	13,160.00	1,040.00
Total	**150,000.00**	**106,846.00**	**43,154.00**

Figure 6. Profit
Source: Original Survey Results

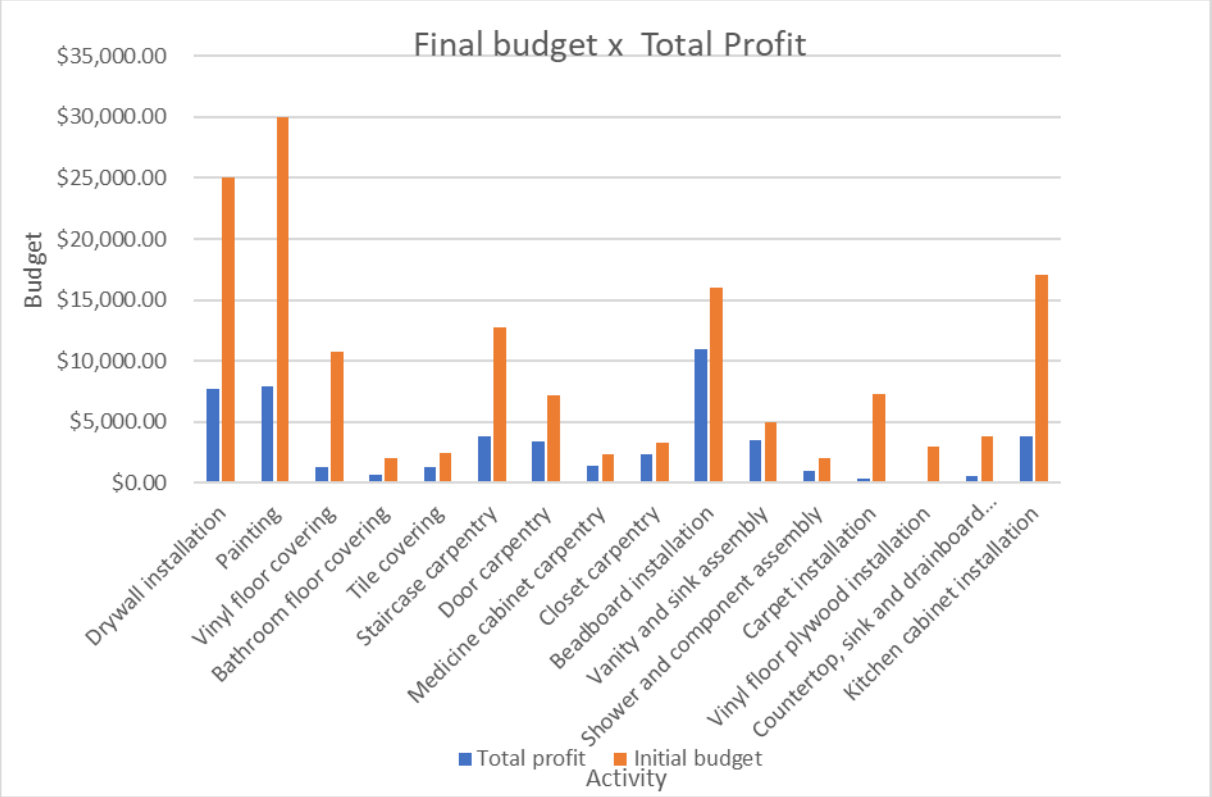

Figure7. Final budget and total profit
Source: Original Survey Results

3. Conclusion(s) or Final Considerations

In the initial phase of the project, some resistance points were observed during the implementation of the methodology, mainly regarding the team composed of subcontractors, since it was a methodology unknown to most of them. Despite the initial resistance, it was possible to notice an adherence on the part of those involved, when the work began. It was also notable that before the project, the works were sequenced in a disorganized manner, mainly regarding the control of documentation, costs and deadlines. The project brought great improvements in this sense, generating historical data that will serve as a basis for new projects.

With regard to the use of cost management tools, it is considered that the objective of this case study was achieved, mainly regarding the completion performance index (IDPT), since it allowed a predictive analysis by pointing out deviations related to delays in the schedule, and consequently in the cost of some activities. This allowed for important decision-making, preventing such deviations from compromising the reserves determined at the beginning of the project. Regarding the 30% gross profit expected by the end of the project, the project achieved 28.77%. It is also worth mentioning that the results left a great impression and satisfaction on the part of the client and the sponsor after the project was

completed, both in relation to the new practices applied, which provided great learning for those involved, and also the final result.

It can be concluded that cost management aspects are essential for obtaining better results in projects. It is also suggested that, for future projects, improvements in the development of schedules should be made, as well as the use of more structured software to control deadlines and subcontracted services.

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NOTE: "**During the preparation of this work the author(s) used ChatGPT in order to TRANSLATE. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.**"

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3 Considerações Finais

Nessa parte você deve apresentar as conclusões referentes aos objetivos propostos para o trabalho final de forma clara e com a intenção de mostrar o que se obteve com o resultado

da pesquisa. Também é recomendável escrever um trecho com sugestões para trabalhos futuros.

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