Factors That Affect Cost and Time Using Earned Value In Development Projects

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KEYWORDS	ABSTRACT
boarding school construction; project performance evaluation; earned value method	The purpose of this study is to find out factors that affect cost and time using earned value in development projects. This process involves steps such as determining the project background, literature review to deepen understanding, data collection through Time Schedules, Budget Plans (RAB), weekly progress reports, and actual costs. Effective project management is the key to success in constructing the boarding school of SMA Muhammadiyah 3 Tulangan. Despite facing various challenges such as design changes, inclement weather, and limited workforce resources, the project is monitored using the Earned Value Method. Analysis of BCWS, BCWP, ACWP, SV, CV, SPI, and CPI indicates initial delays and budget overruns, but significant improvement later on. Despite weekly cost variations, the project remains financially manageable. The conclusion shows time delays but cost performance is under control. This underscores the importance of project performance evaluation and the use of the Earned Value Method in construction projects.

Introduction

In the world of construction, the success of a project is not only determined by the physical completion of construction, but also by controlling costs, quality and time (Alkas et al., 2023). This is a basic principle in project management which is applied in various industrial sectors, including the construction of the Muhammadiyah 3 Tulangan High School dormitory. In this context, efforts to achieve project success involve careful planning, scheduling and control, taking these aspects into account (Arifin et al., 2023). Project management is a series of activities that aim to plan, schedule and control the course of a project in order to achieve the desired goals, both in terms of time, quality and cost (Muniroh et al., 2021). In the context of the construction of the MBS dormitory, project management is crucial to ensure that construction goes according to plan and on time.

However, there is often a discrepancy between the initial plan and the realization in the field, which can result in delays and increased costs for the project. This is the main

challenge that must be overcome in carrying out the MBS dormitory construction project (Asmoro et al., 2023). Scheduling planning that does not consider limited labor resources is one of the problems that must be analyzed carefully (Pratama, 2022). In dealing with scheduling with limited resources, systematic efforts need to be made to determine standards that are in accordance with planning targets or consider possible deviations between implementation and project standards which must be carried out at the beginning and end of project development implementation, which is better known as project control (Siswanto & Salim, 2018). In 2023, SMA Muhammadiyah 3 Tulangan launched the Muhammadiyah Boarding School (MBS) program, which requires the school to provide dormitories for its students (Bonny et al., 2022). However, the number of MBS students is increasing from year to year, causing the existing dormitories to be insufficient. To overcome this, it was decided to build a new dormitory that could accommodate more students (Christy et al., 2023).

CV. Tiga Anugerah Utama was appointed as the provider to carry out the construction of this new dormitory (Ismail & Darkasyi, 2023). The contract for the construction of the dormitory began on 23 November 2023 and is expected to be completed on 26 May 2024, so that it can be used when the new school year starts in June 2024 (Pamungkas & Andreas, 2021). However, throughout the project implementation, various obstacles occurred which affected the progress of the project (Indramanik et al., 2022). One of them is a design change that is made midway without changing the contract value, but only by making a Contract Change Order (CCO). These changes include changes to the building structure and additional rooms, which have implications for the cost and time of project implementation (Irawan et al., 2019).

Apart from that, unpredictable weather, especially frequent rain in Sidoarjo, is also a factor that slows down project progress. Workers were unable to work optimally due to unfavorable weather conditions, and material delivery was hampered because the road to the project site was slippery (Proboretno et al., 2024). This causes increased costs and delays in project implementation. Another obstacle faced is the lack of professional workers in their fields and the lack of ability to manage existing resources optimally (Riduwan et al., 2023). This affects work efficiency and productivity in the field and has the potential to cause delays in project completion. In addition, the decision not to purchase new materials for formwork also slowed down the construction process, even though it had the potential to save costs (Ritonga et al., 2023).

Even though the initial contract was only to build the ground floor, the contractor decided to continue construction up to the 3rd floor with a loan from the contractor and approval from the school. This is done without changing the project implementation time, but still guarantees that the building can be used in the new school year (Sujarwo & Oetomo, 2022). In facing these challenges, a method is needed that can help control project costs and time. One method used is the Earned Value Method, which integrates cost and time to evaluate project performance. This method allows project planners to predict the length of time it will take for the project to be completed and to know the amount of costs incurred until the project ends. Thus, the use of the Earned Value Method is expected to help in controlling the performance of the Muhammadiyah 3 Tulangan High School MBS dormitory construction project, as well as ensuring that the project can be completed on time and in accordance with the predetermined budget.

Research Methods

The research method for the Muhammadiyah Boarding School Development project at SMA Muhammadiyah 3 Tulangan is a structured process carried out to analyze project performance and estimate costs and project completion time accurately.

This process involves steps such as determining the project background, literature review to deepen understanding, data collection through Time Schedules, Budget Plans (RAB), weekly progress reports, and actual costs. These data are the basis for analyzing project performance by calculating indicators such as BCWS, BJWP, ACWP, CV, SV, CPI, and SPI. Calculation of estimated costs and time for project completion uses formulas that have been determined based on the data that has been collected. These estimates are important to provide an accurate picture of resource requirements and expected project schedule. After that, the researcher concludes the project performance and provides estimates of the cost and time for project completion as a basis for stakeholders. This method is carefully designed to ensure proper data collection and in-depth analysis to provide a comprehensive understanding of project performance.

Results and Discussions

Recapitulation of the results of BCWS, BCWP and ACWP calculations

In monitoring the progress of the Muhammadiyah Boarding School Dormitory Construction project for SMA Muhammadiyah 3 Tulangan, we carried out an evaluation using important indicators such as Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), and Actual Cost of Work Performed (ACWP). The weekly data listed in table 1 below provides an overview of how the project is progressing in terms of cost planning and cost realization over the specified time.

Table 1 shows a comparison between planned costs to be achieved (BCWS), actual costs achieved (BCWP), and actual costs incurred (ACWP) during the first 15 weeks of project implementation. From this data, we can evaluate whether the project is running according to the predetermined cost plan and understand how the project costs are realized.

Table 1 Recapitulation of BCWS, BCWP, and ACWP calculation results

Week to	BCWS	BCWP	ACWP
1	4.484.442,31	3.000.000,00	246.080.500,00
2	75.804.683,86	8.753.500,00	251.280.500,00
3	174.349.730,08	64.032.401,31	336.130.600,00
4	272.894.776,30	133.470.044,19	359.524.000,00
5	371.439.822,52	298.420.282,61	397.366.068,00
6	457.735.391,43	477.083.229,15	430.143.568,00
7	586.159.877,02	626.295.393,18	464.850.218,00
8	769.244.924,76	865.650.315,09	489.217.218,00
9	1.033.135.158,57	1.055.757.015,95	594.681.718,00
10	1.299.107.250,20	1.227.673.105,24	650.083.718,00
11	1.502.795.964,89	1.396.394.111,75	667.422.118,00
12	1.685.502.190,22	1.580.565.545,74	691.585.018,00
13	1.868.208.415,55	1.951.272.869,19	869.537.474,00
14	2.050.914.640,87	2.021.090.443,09	963.930.274,00
15	**2.396.739.592,51**	**2.204.079.461,19**	**997.423.774,00**

Source: Researcher's Process, 2024

The data in table 1 shows significant improvements in performance and cost efficiency after the initial few weeks showing very high actual costs compared to the planned budget and work performed. The project gradually showed improvements in cost management and work efficiency, although some challenges remained until the last week analyzed.

Calculation of Schedule Variance (SV) and Cost Variance (CV) Values

To monitor the progress of the Muhammadiyah Boarding School Dormitory Construction project for SMA Muhammadiyah 3 Tulangan, the Schedule Variance (SV) and Cost Variance (CV) were calculated. SV measures schedule differences, while CV indicates cost differences. Table 2 displays the weekly values of SV and CV. Negative values indicate delays and greater costs, while positive values indicate the project is on track or ahead of schedule with costs lower than budget.

Table 2 Schedule Variance (SV) Values and Cost Variance Values (CV)

Week to	SV	Information	CV	Information
1	-1.484.442,31	Negative	-243.080.500,00	Negative
2	-67.051.183,86	Negative	-242.527.000,00	Negative
3	-110.317.328,77	Negative	-272.098.198,69	Negative
4	-139.424.732,11	Negative	-226.053.955,81	Negative
5	-73.019.539,92	Negative	-98.945.785,39	Negative
6	19.347.837,70	Positive	46.939.661,15	Positive
7	40.135.516,14	Positive	161.445.175,18	Positive
8	96.405.390,31	Positive	376.433.097,09	Positive
9	22.621.857,36	Positive	461.075.297,95	Positive
10	-71.434.145,00	Negative	577.589.387,24	Positive
11	-106.401.853,17	Negative	728.971.993,75	Positive
12	-104.936.644,52	Negative	888.980.527,74	Positive
13	83.064.453,60	Positive	1.081.735.395,19	Positive
14	-29.824.197,83	Negative	1.057.160.169,09	Positive
15	-192.660.131,37	Negative	1.206.655.687,19	Positive

Source: Researcher's Process, 2024

In weeks 1-5, the project experienced delays and costs exceeded budget (negative SV and CV values). Starting from weeks 6 to 9, the project is running on schedule and costs are below budget (positive SV and CV values). Weeks 10-12 show delays but costs remain under control (negative SV, positive CV). At week 13, the project was back on schedule and on cost (positive SV and CV values). However, in week 14-15 the project experienced delays again even though costs remained under control (negative SV, positive CV).

Calculation of Schedule Performance Index (SPI) and Cost Performance Index (CPI)

In monitoring the progress of the Muhammadiyah Boarding School Dormitory Construction project for SMA Muhammadiyah 3 Tulangan, the Schedule Performance Index (SPI) and Cost Performance Index (CPI) values were calculated. SPI measures project time efficiency by comparing planned work and completed work, while CPI measures cost efficiency by comparing budgeted costs and incurred costs. Table 3 below displays the SPI and CPI values for each week in the project. SPI and CPI values of less than 1 indicate less efficient time and cost performance, while values of more than 1 indicate more efficient performance.

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Table 3 Schedule Performance Index (SPI) and Cost Performance Index (CPI)

Week To	SPI	Information	CPI	Information
1	0,6690	Not on Target	0,0122	Poor Cost Performance
2	0,1155	Not on Target	0,0348	Poor Cost Performance
3	0,3673	Not on Target	0,1905	Poor Cost Performance
4	0,4891	Not on Target	0,3712	Poor Cost Performance
5	0,8034	Not on Target	0,7510	Poor Cost Performance
6	1,0423	On Target	1,1091	Good Cost Performance
7	1,0685	On Target	1,3473	Good Cost Performance
8	1,1253	On Target	1,7695	Good Cost Performance
9	1,0219	On Target	1,7753	Good Cost Performance
10	0,9450	Not on Target	1,8885	Good Cost Performance
11	0,9292	Not on Target	2,0922	Good Cost Performance
12	0,9377	Not on Target	2,2854	Good Cost Performance
13	1,0445	On Target	2,2440	Good Cost Performance
14	0,9855	Not on Target	2,0967	Good Cost Performance
15	0,9196	Not on Target	2,2098	Good Cost Performance

Source: Researcher's Process, 2024

SPI and CPI data show that the project experienced initial challenges in achieving targets, especially in terms of time delays and poor cost performance. However, as time went by, project performance began to improve, with target achievement and better cost performance. Although there were several periods with time performance challenges, cost performance was maintained well throughout the project.

Calculation of Estimate To Schedule (ETS), Estimate At Schedule (KAS) and Estimate To Complete (ETC) Remaining Costs

Analysis of the performance of the Muhammadiyah Boarding School Dormitory Construction project for SMA Muhammadiyah 3 Tulangan requires regular evaluation of the Cost Budget Plan (RAB), Earned Value (BCWP), Cost Performance Index (CPI), and residual cost estimates (ETC). The following table presents weekly data regarding RAB, BCWP, CPI, and ETC during the project period.

Table 4 Estimate To Schedule (ETS) Values, Estimate At Schedule (EAS) and Estimate To Complete (ETC) Remaining Costs

Week	RAB	BCWP	CPI	ETC
	1	2	3	$3 = 1 - 2$ ➔ (<50%) $4 = (1-2)/3$ ➔ (>50%)
1	5.617.188.890,13	3.000.000,00	0,0122	5.614.188.890,13
2	5.617.188.890,13	8.753.500,00	0,0348	5.608.435.390,13
3	5.617.188.890,13	64.032.401,31	0,1905	5.553.156.488,82
4	5.617.188.890,13	133.470.044,19	0,3712	5.483.718.845,94
5	5.617.188.890,13	298.420.282,61	0,7510	5.318.768.607,52
6	5.617.188.890,13	477.083.229,15	1,1091	5.140.105.660,98
7	5.617.188.890,13	626.295.393,18	1,3473	4.990.893.496,95
8	5.617.188.890,13	865.650.315,09	1,7695	4.751.538.575,04
9	5.617.188.890,13	1.055.757.015,95	1,7753	4.561.431.874,18
10	5.617.188.890,13	1.227.673.105,24	1,8885	4.389.515.784,89

11	5.617.188.890,13	1.396.394.111,75	2,0922	4.220.794.778,38
12	5.617.188.890,13	1.580.565.545,74	2,2854	4.036.623.344,39
13	5.617.188.890,13	1.951.272.869,19	2,2440	3.665.916.020,94
14	5.617.188.890,13	2.021.090.443,09	2,0967	3.596.098.447,04
15	5.617.188.890,13	2.204.079.461,19	2,2098	3.413.109.428,94

Source: Researcher's Process, 2024

It can be observed that the project undergoes various changes over time. Initially, the project showed low performance, especially in terms of low CPI values and high residual cost estimates. However, over time, project performance improved significantly, with CPI consistently increasing and residual cost estimates continuing to decrease. This shows improvements in project cost management over time, which ultimately results in better performance and more efficiency in project budget management.

Calculation of Final total remaining costs Estimate At Completion (EAC)

In the Muhammadiyah Boarding School Dormitory Construction project for SMA Muhammadiyah 3 Tulangan, it is important to monitor actual expenditure (ACWP), estimated remaining costs (ETC), and estimated costs at the end of the project (EAC) to evaluate performance and cost projections. Weekly data related to ACWP, ETC, and EAC has been presented in the following table.

Table 5 EAC Value (Estimate At Complete)

Week	ACWP	ETC	EAC
	1	2	3= 1 +2
1	246.080.500,00	5.614.188.890,13	5.860.269.390,13
2	251.280.500,00	5.608.435.390,13	5.859.715.890,13
3	336.130.600,00	5.553.156.488,82	5.889.287.088,82
4	359.524.000,00	5.483.718.845,94	5.843.242.845,94
5	397.366.068,00	5.318.768.607,52	5.716.134.675,52
6	430.143.568,00	5.140.105.660,98	5.570.249.228,98
7	464.850.218,00	4.990.893.496,95	5.455.743.714,95
8	489.217.218,00	4.751.538.575,04	5.240.755.793,04
9	594.681.718,00	4.561.431.874,18	5.156.113.592,18
10	650.083.718,00	4.389.515.784,89	5.039.599.502,89
11	667.422.118,00	4.220.794.778,38	4.888.216.896,38
12	691.585.018,00	4.036.623.344,39	4.728.208.362,39
13	869.537.474,00	3.665.916.020,94	4.535.453.494,94
14	963.930.274,00	3.596.098.447,04	4.560.028.721,04
15	**997.423.774,00**	**3.413.109.428,94**	**4.410.533.202,94**

Source: Researcher's Process, 2024

It is apparent that projects experience significant cost variations over time. Initially, estimated residual costs (ETC) and estimated costs at the end of the project (EAC) tend to increase, indicating the possibility of project costs shifting higher than expected. However, over time, there was a significant reduction in ETC and EAC, indicating better cost control and efficiency in project expenditure. Despite significant weekly cost variations, the project remained on track to be financially manageable and possible to achieve cost targets at the end of the project.

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Conclusion

Based on the Earned Value analysis that has been calculated in Chapter 4, the conclusions that can be drawn are:

Time performance (Schedule Variance) shows negative results, meaning that the project implementation time is slower than the planned time, while the time productivity index (Schedule Performed Index) 0.919 < 1 indicates that there is a delay in the project implementation time relative to the planned time, and the estimated total implementation time The project (Estimated At Schedule) is 187 calendar days longer than the planning, namely 180 calendar days.

Cost performance seen from the indicator (Cost Variance) shows a positive value of IDR. 1,206,655,687, this means that the project costs in the 15th week of Cost Underrun (costs below plan) performed well, while the cost productivity index (Cost Performed Index) > 1 means that the costs incurred in the 15th week were smaller than the budget, so the performance project implementation is better than planning and estimating the total cost of project implementation (Estimated All Completion), which is Rp. 4,367,677,048.32.

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