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Application of Network Analysis in Improving Project Management Using Project Evaluation and Review Techniques

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ABSTRACT

This study investigates the application of the Project Evaluation and Review Technique (PERT) in improving project management performance using the construction of the Technology Park at the Federal University of Technology (FUT), Minna, as a case study. Secondary data comprising project activities, precedence relationships, and time estimates were obtained from the project's programme of work. PERT analysis was employed using optimistic, most likely, and pessimistic activity time estimates to determine expected activity durations, identify critical activities, compute earliest and latest event times, and evaluate activity slack. The network model developed for the project enabled the identification of activities that significantly influence project completion time and highlighted areas where schedule flexibility exists. The results revealed varying slack times across non-critical activities, with notable float values observed in first-floor construction, roofing, metal works, and service installations. The analysis further established an expected project duration of approximately 61 weeks, providing a more realistic schedule under uncertainty than the original project timeline. The study demonstrates that the application of PERT enhances decision-making, improves resource allocation, facilitates effective monitoring of critical activities, and reduces the likelihood of project delays. It is therefore recommended that construction firms adopt PERT-based network analysis during project planning and execution to achieve improved scheduling accuracy and overall project performance.

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INTRODUCTION

Project management has become an indispensable tool for achieving organizational objectives across construction, engineering, manufacturing, information technology, and research sectors. Effective project management requires careful planning, scheduling, monitoring, and control of activities to ensure that projects are completed within the stipulated time, budget, and quality requirements. Many projects however, experience delays due to inadequate planning, poor resource allocation, design modifications, late delivery of drawings, inspection requirements, and other operational challenges that affect project execution (Danfulani *et al.*, 2023). These delays often result in increased project costs, resource wastage, and reduced stakeholder satisfaction.

To address these challenges, quantitative techniques have been developed to support project planning and decision-making. Among these techniques, network analysis has emerged as one of the most effective approaches for project scheduling and control (Hosseini and Farid 2025). Network analysis techniques play a significant role in enhancing project planning, scheduling, and control, particularly in construction projects characterized by multiple interdependent activities and uncertain activity durations (Figueroa-García *et al.*, 2023). Network analysis is a management technique used to facilitate planning, organizing, scheduling, and controlling project activities through the graphical representation of activity relationships and dependencies (Ahmad, 2012). It provides project managers with valuable information regarding activity durations, resource requirements, critical activities, and project completion times, thereby improving decision-making and project performance. According to Bashir *et al.* (2025), network analysis is an essential quantitative technique for effective management decision-making and has found applications in project management, operations management, systems development, software engineering, and research and development activities.

Network analysis techniques enable project managers to visualize project structures and understand the interrelationships among activities. Sharma (2016) described network analysis as a method for investigating and visualizing relationships among interconnected entities, thereby helping decision-makers identify important components and understand the overall structure of a system. In project management, network analysis facilitates the identification of critical activities whose delays can affect the entire project duration, thereby enabling managers to focus attention and resources on the most significant tasks.

Among the various network analysis techniques, the Project Evaluation and Review Technique (PERT) has gained widespread acceptance for managing projects characterized by uncertainty in activity durations. PERT was developed to analyze and evaluate the time required to complete project activities under uncertain conditions. Unlike deterministic scheduling methods, PERT assumes that activity durations follow a probability distribution and utilizes three time estimates; optimistic, most likely, and pessimistic, to determine expected activity durations and project completion probabilities (Sharma, 2016). This probabilistic approach makes PERT particularly suitable for complex projects where activity durations cannot be predicted with certainty.

The importance of PERT in project management has been highlighted by several researchers. Recent studies indicate that the Program Evaluation and Review Technique (PERT) and the Critical Path Method (CPM) remain among the most widely used techniques for planning and scheduling large-scale projects (Zhasmukhambetova *et al.*, 2025). These techniques assist project managers in estimating project completion times, controlling resources, and ensuring that projects are completed within the stipulated schedule and budget. Furthermore, Kerzner (2017) emphasized that PERT enables managers to identify critical activities, evaluate scheduling constraints, and assess potential risks, thereby facilitating informed decision-making throughout the project life cycle.

Empirical studies have demonstrated the effectiveness of PERT in improving project outcomes. Ukamaka (2020) applied PERT and CPM to a building construction project and found that PERT provided a more efficient project completion estimate with a probability of project completion of 99.87%. Similarly, Singh *et al.* (2023) reported that the application of PERT and CPM in project planning and scheduling resulted in an average reduction of 15% in project duration. Mansur e*t al.* (2024) employed PERT and CPM to develop an optimal management schedule for Master's degree programmes in selected Nigerian universities and found a high probability of completing the programme within the estimated timeframe. Likewise, Oladimeji *et al.* (2023) applied PERT and CPM to a university building construction project and successfully identified the critical path, estimated activity durations, and evaluated the probability of project completion within the stipulated period.

Despite the demonstrated benefits of PERT, project delays continue to be prevalent in many construction projects due to inadequate scheduling practices and ineffective project monitoring. Construction projects often involve numerous interdependent activities, limited resources, and uncertain environmental conditions, making effective planning and scheduling crucial for successful project delivery. The application of PERT offers a systematic framework for identifying activity dependencies, estimating project durations, evaluating completion probabilities, and allocating resources efficiently. Consequently, the adoption of PERT-based network analysis can significantly enhance project planning, scheduling, and control, thereby improving project performance and reducing the likelihood of delays.

This study therefore examines the application of network analysis in improving project management using the Project Evaluation and Review Technique (PERT). The study focuses on the analysis of project activities and their relationships to determine critical activities, estimate project completion times, and provide insights that can enhance decision-making and resource utilization in project execution. The findings are expected to contribute to the growing body of knowledge on network-based project management techniques and provide practical guidance for project managers seeking to improve project performance under conditions of uncertainty.

MATERIALS AND METHODS

Study Area

The study was conducted using a Technology Park construction project located within the Main Campus of the Federal University of Technology (FUT), Minna, Nigeria. The project consists of office spaces and lecture rooms and was originally scheduled to commence in July 2024 and be completed in March 2025. However, as of July 2025, the project had not been completed, making it suitable for evaluating the effectiveness of network-based project management techniques.

Research Design

This study adopted a structural analytical research design based on the principles of network analysis and project scheduling. The Project Evaluation and Review Technique (PERT) was employed to analyze project activities, determine activity dependencies, estimate project completion time, and identify critical activities influencing project performance.

The research procedure involved three major stages:

i. Identification of project activities and their precedence relationships.
ii. Development of a project network diagram representing activity interdependencies.
iii. Application of PERT computations to determine expected activity durations, project completion time, and critical activities

Data Collection

Secondary data were obtained from the Physical Planning and Development Unit (PPDU) of the Federal University of Technology, Minna. The project programme of work served as the primary source of information. The data included activity descriptions, predecessor relationships, and activity duration estimates required for network construction and scheduling analysis.

The project consisted of eighteen (18) major activities comprising approximately fifty (50) sub-activities. For ease of analysis, activities were coded alphabetically from A to R, and activity durations were recorded on a weekly basis as captured in Table 1.

Table 1: PERT Activity Data for the Technology Park Construction Project

Activity	Immediate Predecessor	Optimistic Time (t_o)	Most Likely Time (t_m)	Pessimistic Time (t_p)	$4t_m$	Expected Time (Te) = (t_o+$4t_m$+t_p) /6
A	-	1	1	2	4	1.2
B	A	1	1	4	4	1.5
C	A	0	0	5	0	0.8
D	B, C	1	1	6	4	1.8
E	D	1	1	8	4	2.2
F	E	2	2	10	8	3.3
G	F	7	7	12	28	7.8
H	G	9	9	15	36	10
I	G	3	3	20	12	5.8
J	H, I	2	2	28	8	6.3
K	J	0	0	30	0	5.0
L	I	0	0	32	0	5.3

Activity	Immediate Predecessor	Optimistic Time (t_o)	Most Likely Time (t_m)	Pessimistic Time (t_p)	$4t_m$	Expected Time (Te) = (t_o+$4t_m$+t_p) /6
M	I	1	1	34	4	6.5
N	I	0	0	36	0	6
O	M, N	1	1	38	4	7.2
P	0	1	1	40	4	7.5
Q	P	0	0	42	0	7.0
R	Q	1	1	44	4	8.2

Network Development

The project activities were translated into a network model to illustrate the logical relationships among tasks. Activities were represented as nodes connected according to their precedence relationships. The network was developed following standard project network construction procedures, ensuring that all activity dependencies were accurately represented.

Dummy activities were introduced where necessary to preserve logical sequencing without consuming additional time or resources. During network construction, the following questions guided activity placement:

i. Which activities must be completed before the current activity can begin?
ii. Which activities immediately follow the current activity?
iii. Which activities occur concurrently with the current activity?

The completed network provided a graphical representation of project workflow and served as the basis for subsequent PERT analysis.

PERT Analysis

The Project Evaluation and Review Technique (PERT) was employed because it accommodates uncertainty in activity durations through the use of three time estimates:

i. Optimistic time (a): the minimum possible time required to complete an activity under favorable conditions.
ii. Most likely time (m): the most probable duration of an activity.
iii. Pessimistic time (b): the maximum expected duration under unfavorable conditions.

The expected duration for each activity was computed using:

$$t_E = (t_O + 4t_M + t_P)/6 \quad (1)$$

Where: t_E is expected activity duration,
t_O is optimistic time
t_M is most likely time,
t_P is pessimistic time.

Scheduling Computations

Forward Pass Analysis

Forward pass calculations were performed to determine the earliest start (ES) and earliest finish (EF) times of project activities using:

$$EF = ES + D \quad (2)$$

Where: ES = Earliest Start time,
EF = Earliest Finish time,
D = Activity Duration.

For activities with multiple predecessors, the maximum earliest finish value was selected as the earliest start time of the succeeding activity.

Backward Pass Analysis

Backward pass calculations were conducted to determine the latest start (LS) and latest finish (LF) times using:

$$LS = LF - D \quad (3)$$

Where: LF = Latest Finish time,
LS = Latest Start time,
D = Activity Duration.

Float Determination

Activity float (slack) was calculated to identify scheduling flexibility and non-critical activities:

$$TF = LS - ES = LF - EF \quad (4)$$

Where: TF represents Total Float.

Activities with positive float values could be delayed without affecting the overall project completion time.

Critical Path Identification

The critical path was identified as the longest sequence of dependent activities with zero float. Activities satisfying the criticality condition;

ES=LS and EF=LF (5)

Were classified as critical activities. Any delay in these activities would directly delay project completion.

Data Analysis

The network model was analyzed using PERT scheduling procedures to determine:

i. Expected duration of each activity.
ii. Earliest and latest occurrence times.
iii. Total float for each activity.
iv. Critical path activities.
v. Expected project completion time.

The results were subsequently used to evaluate the effectiveness of network analysis in improving project planning, scheduling, monitoring, and control under conditions of uncertainty.

RESULTS AND DISCUSSION

Project Activity Network and Expected Duration

Application of the Project Evaluation and Review Technique (PERT) to the Technology Park construction project resulted in the development of a network model comprising eighteen major activities and approximately fifty sub-activities. The project activities were arranged according to their precedence relationships, and expected activity durations were computed using optimistic, most likely, and pessimistic time estimates. The PERT analysis showed that the project would require an expected completion time of 61 weeks, compared with the initially planned duration of 32 weeks. Thus, the analysis indicated an additional 29 weeks beyond the original schedule, suggesting that the initial project duration underestimated the level of uncertainty associated with activity completion.

Identification of Critical Activities

The critical activities were identified from the network based on zero total float. Twelve of the eighteen major activities were found to be critical. These activities are presented by Figure 1 below:

A → B → D → E → F → G → I → M → O → P → Q → R

Figure 1: Critical Activities Diagram

The critical activities form the critical path of the project and have zero slack time. Consequently, any delay in these activities would directly affect the overall project completion time.

Earliest and Latest Event Times

Forward and backward pass computations were used to determine the earliest start (ES), earliest finish (EF), latest start (LS), and latest finish (LF) times for each activity. The results revealed that the critical activities had identical earliest and latest times, confirming that they possessed zero float and therefore constituted the critical path.

Table 2. Forward and Backward Pass Computations for Project Activities

Activity	Possible Start Time		Possible Finish Time		Slack Time or Total Float
	ES	LS	EF	LF	LS-ES or LF-EF
A.	0	0	1	1	0
B.	1	1	3	3	0
C.	1	2	2	3	1
D.	3	3	5	5	0
E.	5	5	7	7	0
F.	7	7	10	10	0
G.	10	10	18	18	0
H.	18	40	28	50	22
I.	18	18	24	24	0
J.	28	50	34	56	22
K.	34	56	39	61	22
L.	24	56	29	61	32
M.	24	24	31	31	0
N.	24	25	30	31	1
O.	31	31	38	38	0
P.	38	38	46	46	0
Q.	46	46	53	53	0
R.	53	53	61	61	0

The application of the Project Evaluation and Review Technique (PERT) to the Technology Park construction project demonstrated the usefulness of network analysis in enhancing project planning and scheduling under conditions of uncertainty. The PERT model developed for the project enabled the determination of expected activity durations, identification of critical activities, and estimation of project completion time. The analysis revealed an expected project duration of 61 weeks, which exceeded the initially planned duration of 32 weeks. This disparity suggests that the original schedule underestimated the uncertainties associated with activity execution and highlights the importance of probabilistic scheduling techniques in construction project management.

The results further showed that twelve activities (A, B, D, E, F, G, I, M, O, P, Q, and R) formed the critical path and possessed zero total float. Consequently, delays in any of these activities would directly affect the overall project completion time. This finding underscores the importance of identifying critical activities during project planning, as such information enables project managers to prioritize resources and intensify monitoring efforts on activities that have the greatest influence on project completion. The result agrees with the observations of Kerzner (2017), who noted that PERT facilitates the identification of critical activities and assists managers in evaluating scheduling constraints and project risks.

The slack time analysis revealed that some activities possessed considerable scheduling flexibility. Activities H, J, and K had float values of 22 weeks, while Activity L had the highest float value of 32 weeks. Activities C and N had slack values of one week each. These non-critical activities could tolerate delays within their respective float periods without affecting the overall completion time of the project. Such information is valuable in resource allocation and schedule optimization because resources can be redirected from non-critical activities to critical activities when necessary. This supports the assertion of Ahmad (2012) that network analysis provides project managers with useful information for planning, scheduling, and controlling project operations.

The findings of this study are consistent with previous empirical investigations. Ukamaka (2020) demonstrated the effectiveness of PERT in improving project completion estimates in building construction projects, while Singh et al. (2023) reported that the application of PERT and CPM reduced project duration and enhanced scheduling efficiency. Similarly, Oladimeji et al. (2023) successfully employed network analysis techniques to identify critical paths and estimate project completion probabilities in construction projects. The present study therefore reinforces the view that PERT remains an effective tool for managing complex projects characterized by uncertain activity durations.

Furthermore, the study highlights the significance of network analysis as a decision-support tool in project management. By incorporating optimistic, most likely, and pessimistic activity times, PERT provides more realistic project schedules than deterministic approaches. The resulting schedule information can assist project managers in anticipating delays, allocating resources efficiently, and improving overall project performance. Hence, the application of PERT contributes to enhanced project monitoring, better utilization of resources, and reduction in schedule overruns.

CONCLUSION

This study examined the application of network analysis in improving project management using the Project Evaluation and Review Technique (PERT). The analysis of the Technology Park construction project at the Federal University of Technology, Minna, demonstrated the effectiveness of PERT in handling uncertainty associated with project activities and providing realistic estimates of project completion time. The study identified twelve critical activities that constituted the critical path and established an expected project duration of 61 weeks. In addition, the slack time analysis revealed varying degrees of scheduling flexibility among non-critical activities, thereby providing useful information for effective resource allocation and project control. These findings indicate that PERT is an effective technique for project planning, scheduling, monitoring, and decision-making.

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