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Research Article

Efficient Project Management Schedule for MSc Studies in Northwestern Nigerian Universities Employing CPM and PERT Techniques

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Abstract— Effective project execution relies heavily on sound planning and scheduling methods. Unfortunately, planning and scheduling often pose challenges due to their complexity and time consuming nature. This research focuses on identifying the critical activities involved in MSc studies and developing an optimal project management schedule for MSc students in chosen universities in Northern Nigeria, utilizing CPM and PERT methodologies. Data was collected through a survey questionnaire distributed to final year Masters Students and MSc holders in the selected universities, employing a convenience sampling approach. Critical activities identified include; Review of Literature, Writing of Proposal, Proposal Defence, Generation of the Results, and Presentation of the Results, Thesis Writing, Submission of Thesis, Internal Defence, Final Correction, Final Submission and Graduation. The study determined an optimal Master's program duration of 35 months, with a high probability (0.99) of completing the program within this timeframe.

Keywords— Project Management, Probabilistic computations, Network analysis, Optimal Schedule, Critical Path

1. Introduction

Project management involves the necessary practices for a group to achieve defined goals and meet success standards within specified timelines. Until recently, there was no universally accepted project management approach, with managers relying on their experience and judgment. As a result, each project manager typically employed a varied system, often using tools like Gantt charts or bar charts. However, given the increasing complexity of projects, there is a need for advanced tools that can address their intricate requirements [1]. Successful project management necessitates thorough scheduling and cost plans, covering initiation, planning, implementation, monitoring, and completion [2]. Efficient project management is crucial for any organization [3]. Project management enables the effective utilization of time and resources [4]. Research indicates a shortage of proficient planners, particularly concerning the time constraints experienced by experienced project managers in planning construction projects [5]. Effective time and resource management are crucial in academia for obtaining higher certificates [7]. Lack of sufficient project planners is critical in every institution [8].

1.1 Objectives of the Study

- Identify the critical activities and milestones involved in MSc studies
- Determine the optimal sequence and timing of activities in MSc studies.
- Evaluate the impact of implementing CPM and PERT methodologies in MSc studies.

2. Related Work

The field of project management has garnered considerable attention, with numerous papers exploring both the theory and practical applications of project management. Researchers have proposed innovative methods for assessing activity productivity, interruptions/restrictions, and intervals in highway projects. One study introduced a chart depicting activity landscapes on the x-axis representing time periods and the y-axis indicating positions within the direct project [9]. Another research project visualized tedious events as constant or changing slope lines over time, suggesting that discrete activities could be presented in the linear schedule, with the network schedule providing additional details [10].
Critical chain project management (CCPM) was highlighted as a method that enhances project performance and facilitates continuous improvement in project organization and management [11]. Additionally, a simplified CPM/PERT simulation technology was introduced to analyze risks and evaluate alternative scenarios in project management [12]. Critical chain programming was emphasized as valuable in improving project performance when applied to project management [13].

Simulation technology was employed to estimate the duration of road projects, although concerns were raised about its compatibility with the linear relationship in road project activities [14]. Another study focused on incorporating multiple resource calendars' impact on CPM scheduling, proposing a technique to accurately assess an activity's effect on the project's total duration [15]. Critical Chain (CC) and Theory of Constraint (TOC) calculations were identified as essential factors promoting the development of the construction field, [16].

A study advocated for the application of Critical Chain Project Management (CCPM) to private projects, concluding that it offers a more effective method for project management [17]. Another research effort utilized CPM to create a consistent project plan, acknowledging that while CPM can reduce schedule uncertainties, small changes in activities may render the planned time infeasible [17]. The Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT) were identified as corporate instances of setup programming procedures aiding project managers in monitoring task progress [19]. Furthermore, CPM was employed to analyze the planning of biogas plant construction, emphasizing the importance of properly managing project schedules to meet deadlines and budgets [20].

From the existing researches, there is a gap in the application of project management methodologies in Postgraduate studies. Hence, addressing and filling that research gap is the core aim of the study.

3. Theory/Calculation

3.1 Critical Path Analysis

Compute the Earliest Start Time (EST) (by forward pass) and the Latest Completion Time (LCT) (by backward pass) with equations 1, 2 and 3, 4 respectively:

Calculate the Slack using equation 8:

$ES_{ij} = max(EF_i)$ (1)

$EF_{ij} = ES_{ij} + D_{ij}$ (2)

$LS_{ij} = LF_j - D_{ij}$ (3)

$LF_{ij} = \min(LS_{ij})$ (4)

Where; ES_{ij} is earliest start of the activity, EF_i is earliest finish of the starting node, EF_{ij} is the earliest finish of the activity, D_{ij} is the duration of the activity, LS_{ij} is the latest start of the activity, LF_j is the latest finish of the ending node and LF_{ij} represents latest finish of the activity.

Calculate the critical path using equations 5, 6 and 7 respectively.

$EST_i = LCT_i$ (5)

$EST_j = LCT_j$ (6)

$EST_j - EST_i = LCT_j - LCT_i = D_{ij}$ (7)

3.2 PERT Computations

PERT utilizes three-time estimates, namely optimistic, most likely, and pessimistic, making it a probabilistic approach. The optimistic time (a) represents the shortest possible duration to complete a project under favourable conditions. Pessimistic time (b) signifies the maximum time required if things go awry, while most likely time (m) indicates the most probable duration assuming everything progresses smoothly [21]. PERT relies on a beta probability distribution for its estimates, and the expected time for each activity is approximated using a weighted average.

By assessing the variability in crucial tasks, it becomes possible to estimate the likelihood of project completion by a specified date, assuming a standard probability distribution for the critical path. The steps for determining the anticipated project completion time through the Program Evaluation and Review Technique (PERT) are outlined as follows:

a. Develop the activity network using circles (nodes) and arrows.
b. Compute the expected durations and variances for each activity using equations; 8 and 9:

Mean of expected time (t_e) = $\frac{a+4m+b}{6}$ (8)

V= $\sigma^2 = (\frac{b-a}{6})^2$ (9)

Where; t_e is the expected time, a to represents optimistic time, m is the most likely time, b represents pessimistic time, V denotes variance and σ is the standard deviation.

4. Experimental Method/Procedure/Design

The outcomes of the CPM related samples involved interviewing 128 individuals with Master degrees and some final-year MSc students. Among them, 51 were from Bayero University, Kano, 29 from Yusuf Maitama Sule University, Kano, and 48 from Aliko Dangote University of Science and Technology, Wudil. These individuals were selected both conveniently and purposefully to share insights through a questionnaire regarding the time required for various activities within their Master programs at these institutions.

Subsequently, calculations were performed based on their responses to formulate an optimal project management schedule for Masters Studies in the mentioned universities, as outlined in Table 1 below.

Table 1. Optimal schedule

Activities	**Predecessor**	**Duration (Months)**
Review of Literature (RL)	-	6
Identification of Problem (IP)	RL	1
Writing Proposal (WP)	IP	4
Proposal Defence (PD)	WP	1
Generation of Results (GR)	PD	9
Presentation of Results (PR)	GR	2
Thesis Writing (TW)	PR	4
Submission of Thesis (ST)	TW	2
Internal Defence (ID)	ST	2
External Defence (ED)	ID	1
Final Corrections (FC)	ED	2
Final Submission (FS)	FC	1
Graduation (G)	FS	2
Total		**37**

5. Results and Discussion

5.1 The CPM Activities Diagram

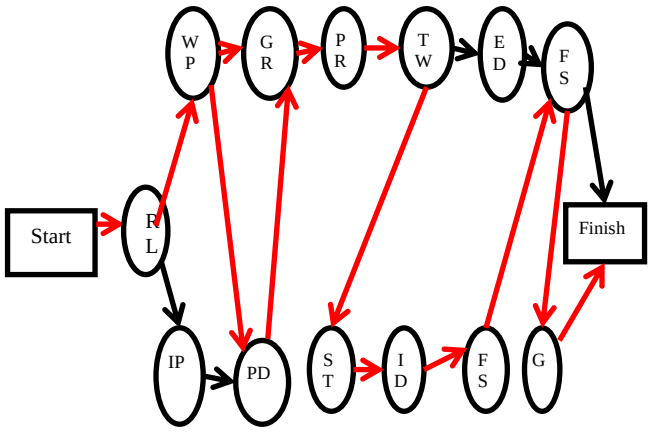

Figure 1: The activities network diagram

5.2 Calculation of Slacks from the CPM Diagram

A slack is the difference between Latest Completion Time (LCT) and Earliest Start Time (EST).

Table 2: Slack of the activities

Activity	Slacks
Review of Literature (RL)	0
Identification of Problem (IP)	3
Writing Proposal (WP)	0
Proposal Defence (PD)	0
Generation of Results (GR)	0
Presentation of Results (PR)	0
Thesis Writing (TW)	0
Submission of Thesis (ST)	0
Internal Defence (ID)	0
External Defence (ED)	6
Final Corrections (FC)	0
Final Submission (FS)	0
Graduation (G)	0

In Table 2, an activity with a zero slack value indicates that such activity is a critical one. Otherwise is a non-critical activity.

5.3 Critical Path and Critical Activities from the CPM diagram

The critical activities and their respective durations are summarized in Table 3 below.

Table 3. Critical activities with their durations from the network diagram

Activity	Duration (Months)
Review of Literature (RL)	6
Writing Proposal (WP)	4
Proposal Defence (PD)	1
Generation of Results (GR)	9
Presentation of Results (PR)	2
Thesis Writing (TW)	4
Submission of Thesis (ST)	2
Internal Defence (ID)	2
Final Corrections (FC)	2
Final Submission (FS)	1
Graduation (G)	2
Total	**35**

From the table above, the critical activities identified are; Review of Literature (RL), Writing Proposal (WP), Proposal Defence (PD), Generation of Results (GR), Presentation of Results (PR), Thesis Writing (TW), Submission of Thesis (ST), Internal Defence (ID), Final Corrections (FC), Final Submission (FS) and Graduation (G). The sum of these activities is 35.

5.4 Computations of the probability using PERT

Results from the administered questionnaire revealed various durations of the three time estimates which are; optimistic, most likely and pessimistic times as seen in Table 4 below.

Table 4. Durations of activities

Activity	Duration (Months)		
	Optimistic (a)	Most likely (m)	Pessimistic (b)
Review of Literature (RL)	5	6	7
Identification of Problem (IP)	2	1	5
Writing Proposal (WP)	3	4	4
Proposal Defence (PD)	1	1	1
Generation of Results (GR)	8	9	10
Presentation of Results (PR)	2	2	3
Thesis Writing (TW)	3	4	5
Submission of Thesis (ST)	2	2	3
Internal Defence (ID)	2	3	4
External Defence (ED)	1	1	7
Final Corrections (FC)	1	2	2
Final Submission (FS)	1	1	2
Graduation (G)	2	3	4
Total	33	39	57

5.5 Calculation of the variances

Computations of the variance of the critical activities were carried out in table 5 below.

Table 5. Critical Activities with expected durations and variances

Critical Activity	Mean of Duration (Months)	Variance
Review of Literature (RL)	6	0.11
Writing Proposal (WP)	4	0.03
Proposal Defence (PD)	1	0
Generation of Results (GR)	9	0.11
Presentation of Results (PR)	2	0.03
Thesis Writing (TW)	4	0.11
Submission of Thesis (ST)	2	0.03
Internal Defence (ID)	2	0.11
Final Corrections (FC)	2	0.03
Final Submission (FS)	1	0.03
Graduation (G)	2	0.11
Total	**35**	**0.70**
σ	$=\sqrt{0.70}$	$=0.84$

From the table above, the probability of completing the project on or before 37 months using the Standard Normal Distribution is given as:

$$Prob\{T \leq 37\} = Prob\left\{\frac{T-\mu}{\sigma} \leq \frac{37-35}{0.84}\right\}$$

$$= Prob\{Z \leq 2.38\} = 0.99$$

Therefore, the probability of completing the program on or before 37 months from the Standard Normal Distribution table is 0.99.

5.6 Discussions
Review of Literature, Writing of Proposal, Proposal Defence, Generation of Results, Presentation of Results, Thesis Writing, Submission of Thesis, Internal defence, Final Correction, Final Submission and Graduation were the critical activities based on the results from the CPM activity diagram. The path through these activities is known as the critical path and the sum of their respective durations shown in Table 3 is 35 months.

The zero-slack value of each of these activities shown in Table 2 indicates that, they cannot be delayed without affecting the project duration. On the other hand, Problem Identification and External Defence were the only non-critical activities as per the results from the CPM activity diagram. Their slack values of 3 and 6 respectively show that these activities can be delayed up to 3 months and 6 months respectively without affecting the project duration.

Calculations using PERT indicated that, the sum of variances of the critical activities is 0.70 and the standard deviation is 0.84. The probability of completing the project/program on or before 37 months was then calculated to be 0.99 using the standard normal distribution table.
It can therefore be concluded that the probability of finishing the program/project within 35 months is 0.99.

6. Conclusion and Future Scope

The Critical Path Method (CPM) and Project Review and Evaluation Technique (PERT) have effectively been employed in the field of Project Management for an MSc program across three chosen universities in Northwestern Nigeria. More precisely, an efficient project management schedule for MSc studies in these universities has been developed through the application of CPM and has been instrumental in identifying both critical and non-critical activities associated with the MSc program in these academic institutions.

Additionally, the likelihood of successfully finishing an MSc program in the chosen universities has been assessed through PERT. The research suggests that MSc students in the selected universities and throughout Nigeria should consider adopting the identified optimal project management schedule as a reference. It is crucial for students to remain aware of both critical and non-critical tasks within an MSc program.
The study has contributed significantly by proposing an optimal schedule for MSc studies. It has also successfully applied the concept of Project Management to MSc studies in the manner presented in this paper which has not been explored.

Data Availability
The data for this research was sourced through interview and questionnaire.

Study Limitations
None.

Conflict of Interest
All Authors declare that they do not have any conflict of interest.

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Authors' Contributions
The research was a collective effort of all authors.
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