Research Article

Examining Effectiveness of Project Scheduling Techniques on Project Performance: A Study of Machine Rebuild Project at Kalumbila Mine

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About Article

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ABSTRACT

This study aimed to examine the effectiveness of project scheduling techniques on project performance, using a machine rebuild project at Kalumbila as a case study. The research was guided by three objectives: To establish the effectiveness of project scheduling strategies on project performance, to determine the relationship between project scheduling techniques and project completion, and to investigate the challenges faced by project managers in adopting and implementing advanced scheduling methodologies. A quantitative research design was employed, targeting a population of 50 individuals comprising 10 top management, 10 middle management, and 30 low management employees at Kalumbila. A probability sampling design was utilized to ensure a representative sample. Data was collected using structured questionnaires and analysed using SPSS. Baseline schedules are deemed essential by 55% for achieving project goals. In relation to project cost management, 47.5% find modern scheduling techniques outperform traditional methods, while 100% agree that optimized resource allocation accelerates project completion. Stakeholder communication and collaboration have a moderate to significant impact on project completion rates, according to 55% and 45% of respondents, respectively. Best practices for successful implementation include strong leadership support (55%) and comprehensive training (35%). Overall, the study underscores the importance of agile methodologies, predictive analytics, and effective stakeholder engagement in optimizing project scheduling. However, it highlights the need to address challenges such as resource constraints, budget limitations, and regulatory impacts to improve scheduling practices.

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1. INTRODUCTION

1.1. Background

Project scheduling is vital for ensuring the successful execution of projects, particularly in developing countries like Zambia. Infrastructure projects are pivotal to Zambia's economic growth, yet only 60% are completed on time, according to the Zambia Institute of Planners (ZIP, 2019). Traditional manual methods dominate the landscape, but modern techniques like Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) are increasingly adopted. Studies by Mwape *et al.* (2021) indicate that projects utilizing these modern methods achieve a 20% improvement in schedule adherence. Additionally, 75% of project managers in Zambia now leverage computerized scheduling tools (ZPMA, 2022), underscoring a shift towards technology-driven practices. Resource constraints further emphasize the need for effective scheduling; projects employing resource leveling reduce wastage by 15% and boost productivity by 25% (MWS, 2020). However, challenges such as limited training, unreliable infrastructure, and external factors like political instability contribute to 40% of project delays (ZCF, 2021). Addressing these issues holistically can significantly enhance project outcomes in Zambia.

1.2. Statement of the Problem

The effectiveness of project scheduling techniques strategies on project performance remains a critical concern in Zambia's project management landscape. Despite efforts to enhance scheduling methodologies, challenges persist, hindering optimal project performance. Additionally, understanding the relationship between project scheduling techniques and project completion is imperative for achieving project objectives within budgetary constraints. Moreover, the adoption and implementation of advanced scheduling methodologies face numerous challenges, impeding the ability of project managers to leverage modern techniques effectively. Statistics reveal that only 60% of infrastructure projects in Zambia are completed within the scheduled timeframe (ZIP, 2019). This statistic underscores the need to establish more effective project scheduling practices to address delays and improve project outcomes. Furthermore, inadequate resource allocation and poor risk management contribute to project delays and cost overruns, exacerbating the challenges faced by project managers (MWS, 2020). To address these issues, stakeholders must collaborate to develop comprehensive solutions that address the root causes of scheduling inefficiencies. Implementing training programs and providing access to advanced scheduling tools can empower project managers to overcome challenges associated with adopting modern methodologies. Furthermore, promoting a culture of risk awareness and proactive mitigation strategies can help mitigate uncertainties and enhance project resilience in Zambia's dynamic environment.

1.3. General objective

The general objective of the study is to examine effectiveness of project scheduling techniques on project performance: a study of a machine rebuild project at Kalumbila mine

1.3.1. Specific objectives

i. To establish the effectiveness of project scheduling techniques strategies on project performance.

ii. To determine the relationship between project scheduling techniques and project completion.

iii. To Investigate the challenges faced by project managers in adopting and implementing advanced scheduling methodologies.

1.4. Theoretical frameworks

Theoretical frameworks provide essential perspectives for analyzing project scheduling effectiveness in Zambia. The PMBOK framework emphasizes structured scheduling, risk, and cost management principles, offering a systematic approach to project execution (PMI, 2017). The Theory of Constraints (TOC) highlights identifying and addressing bottlenecks to improve workflow and overall performance (Goldratt, 1990). The Resource-Based View (RBV) underscores the strategic management of resources like manpower and technology to enhance competitive advantage (Barney, 1991). Finally, Contingency Theory emphasizes aligning scheduling methods with organizational and environmental contexts, such as stakeholder dynamics and regulatory factors (Donaldson, 2001). Together, these frameworks guide tailored, effective project scheduling strategies in Zambia.

2. LITERATURE REVIEW

2.1. Effectiveness of project scheduling techniques strategies on project performance

Empirical studies highlight the effectiveness of project scheduling techniques on project performance in the USA, South Africa, and Zambia. In the USA, the widespread adoption of advanced project management tools like Primavera and MS Project has demonstrated significant improvements in project performance. A study by Kerzner (2019) revealed that projects using tools aligned with Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT) achieved a 25% reduction in project delays and cost overruns. Moreover, the integration of Agile scheduling techniques has been associated with increased adaptability and stakeholder satisfaction in technology and construction projects (PMI, 2020).

In South Africa, infrastructure development projects often grapple with delays and resource constraints. A study by Marnewick *et al.* (2017) showed that adopting modern scheduling tools improved schedule adherence by 18% compared to traditional methods. The research also emphasized the importance of resource leveling techniques in reducing wastage and optimizing project timelines, particularly in government-funded projects. In Zambia, project scheduling faces challenges due to limited access to advanced tools and training. However, projects that employ CPM and PERT techniques report a 20% improvement in adherence to schedules compared to those using manual methods (Mwape *et al.*, 2021).

2.2. Relationship between project scheduling techniques and project completion

Empirical studies from China, Nigeria, and Zambia highlight the

critical relationship between project scheduling techniques and project completion. In China, project management practices have evolved with the integration of advanced scheduling techniques like the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). A study by Zhang et al. (2018) revealed that projects employing these methods achieved an 85% on-time completion rate compared to 68% for projects using traditional methods, indicating significant improvements in efficiency and resource utilization. The research also emphasized the role of technology-driven tools, with 90% of managers leveraging software like Primavera and MS Project to streamline schedules and reduce delays. In Nigeria, project delays remain a major concern, with 70% of public infrastructure projects experiencing schedule overruns (Oyewobi et al., 2016). However, projects incorporating modern scheduling techniques reported a 30% improvement in adherence to timelines. A study by Dada et al. (2020) demonstrated that the use of resource-leveling techniques, combined with computerized tools, reduced resource conflicts and enhanced overall project completion rates. The findings stress the importance of training and capacity-building to address skill gaps in advanced scheduling methodologies. Zambia faces similar challenges, with only 60% of infrastructure projects completed on time (Zambia Institute of Planners, 2019). Mwape et al. (2021) observed that projects utilizing CPM and PERT techniques experienced a 20% improvement in schedule adherence. The integration of computerized tools has further supported timely completion, though external factors like resource constraints and political instability continue to pose challenges (ZCF, 2021). These studies collectively underscore the transformative impact of modern scheduling techniques on project completion across diverse contexts.

2.3. Challenges faced by project managers in adopting and implementing advanced scheduling methodologies

Project managers in the UK, Kenya, and Zambia face distinct yet overlapping challenges when adopting and implementing advanced scheduling methodologies. In the UK, studies highlight resistance to change and insufficient training as significant barriers. A survey by the Association for Project Management (APM) found that 62% of project managers lacked adequate training in advanced tools like Primavera and Microsoft Project, hindering their integration into workflows (APM, 2020). Additionally, complex regulatory requirements and stakeholder alignment often complicate the adoption of these methodologies in large-scale projects.

In Kenya, limited access to advanced technology and resources is a primary challenge. Research by Muriithi and Crawford (2020) indicates that only 45% of Kenyan firms in the construction and IT sectors have access to modern scheduling software, leading to reliance on traditional, manual methods. Financial constraints and inconsistent internet connectivity further exacerbate this issue. Moreover, a lack of skilled personnel trained in advanced techniques like Critical Path Method (CPM) or Program Evaluation and Review Technique (PERT) impedes effective implementation (Kamau & Mweu, 2019). In Zambia, challenges are rooted in inadequate infrastructure, political instability, and resource constraints. A report by the Zambia Institute

of Planners (ZIP) revealed that 40% of project delays result from external factors, including unreliable power supply and economic instability (ZIP, 2019). Additionally, limited access to training programs on advanced methodologies restricts their adoption. Mwape et al. (2021) found that only 30% of project managers in Zambia are proficient in using modern scheduling tools.

3. METHODOLOGY
3.1. Research Design
According to Kothari (2004) a research design is the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure. The nature of the above objective can be classified as one that falls within the realm of a descriptive research study. According to Kothari (2004), descriptive research is described as one that indicates characteristics which are inherent of a particular situation, or individual as well as a group. It goes further by describing the frequency with which something happens.

3.2. Target population
The main population of this study will consist of staff from kalumbila mine. This population is finite, as the number of study participants is known, rather than infinite, where the number of participants would be unknown. The target population includes 10 top management, 10 middle management and 30 low management.

3.3. Sampling procedure
This research employed a survey method, aligning with Kothari's (2004) distinction between census and sample surveys. While a census includes the entire population, this study used a sample survey, focusing on a subset of the population. The first step involved developing a source list, as none was available. A sample size of 50 staff members was determined using methods outlined earlier. Probability sampling, recommended for descriptive studies to minimize bias (Kothari, 2004), was employed to ensure reliable results. This approach addressed the inherent limitations of non-probability sampling in descriptive research.

3.4. Sample size determination
The participants for the study will be drawn from top management, middle management and low management of Kalumbila mine, However, the sample size will be limited to 50 respondents.

3.5. Data collection
For purposes of this study, primary data will be obtained through a questionnaire structured to meet the objectives of the study. The questionnaires will be used because they are straightforward and less time consuming for both the researcher and the participants (Flick, 2017). The questionnaires will have number of sub-sections that were sub-divided based on the major research questions except the first sub-section that meant to capture the background information of the participants like gender, marital status, age, working experience, level of

education. Other sections will address questions to achieve each of the specific objectives of the study. The questions will be both open - ended and closed ended. The closed ended questions helped capture the results that quantified the analysis. The open-ended questions helped in eliciting responses that qualitatively analyzed and helped capture the issues that are relevant to the study but could not be captured by structured questions. The researcher rad ministered the questionnaires to ensure the accuracy of the responses from citizens. Oral interviews with the various members of interest groups will also be conducted by the researcher.

3.6. Data analysis

As already mentioned, this research featured elements of a descriptive study and therefore data will be analyzed descriptively. Questionnaires will be the main instruments use for the collection of data in this study. The data collected will be coded, tabulated and finally frequencies and percentages will be derived. Statistical package for social sciences (SPSS) was the main computer program used; specifically, descriptive statistics were the main area of concentration. Microsoft excel will be used to derive visual aids such as graphs and charts for data presentation. The method chosen to analyze data gathered through the interview will be qualitative content analysis which will be done manually.

3.7. Triangulation

Triangulation is a technique used for analyzing the results from multiple-method research designs. It is most often used as a form of cross checking to validate the results from different kinds of methods, such as the collection of demographics and other information. This study involved the use of the survey method, use of a structured questionnaire or interview guide in an interview, the use of a sample and the use of probability sampling technique to arrive at the sample. Data were coded and thematically analyzed. The collection of data by the researcher identified the complexities related to the context of the study. The surveys were supplemented by the interviews and focus groups. Each research method exposed one aspect of reality. This multi method, multidisciplinary collaborative research was insightful.

3.8. Ethical Considerations

Informed consent will be obtained from all those participating

in the study. The participants were informed about the purpose of the study and they answered the questions anonymously; they were free to skip any question they were not comfortable to answer. Data collection tools will keep safely and confidentially. Information gathered will be used only for the purposes of this academic study. The necessary research authorities were consulted for permission.

4. RESULTS AND DISCUSSION
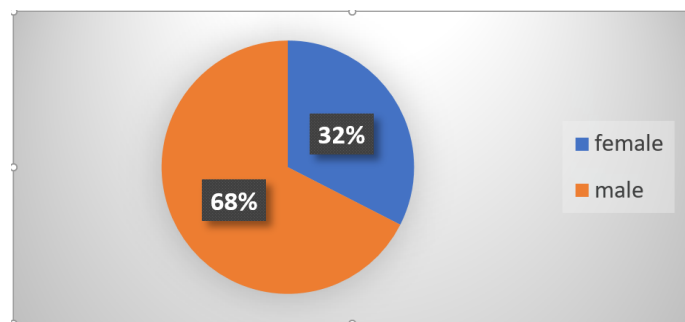### 4.1. Background information

Figure 1. Gender

The study requested the respondent to indicate their gender. 68% of the majority respondents indicated male while 32% of the respondent indicated female.
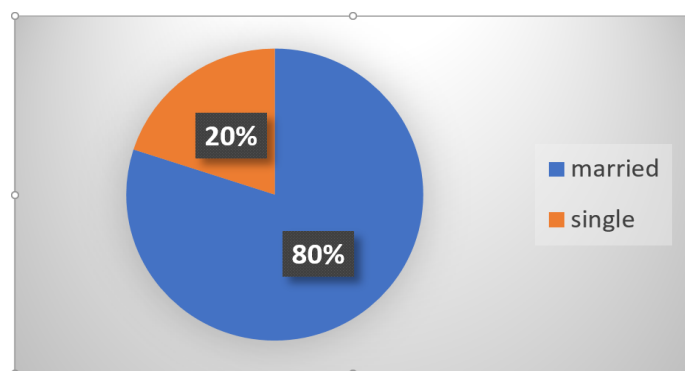

Figure 2. Marital status

The study requested respondents to indicate their marital status. 80% of the majority respondents indicated married while 20% of the respondents indicated single.
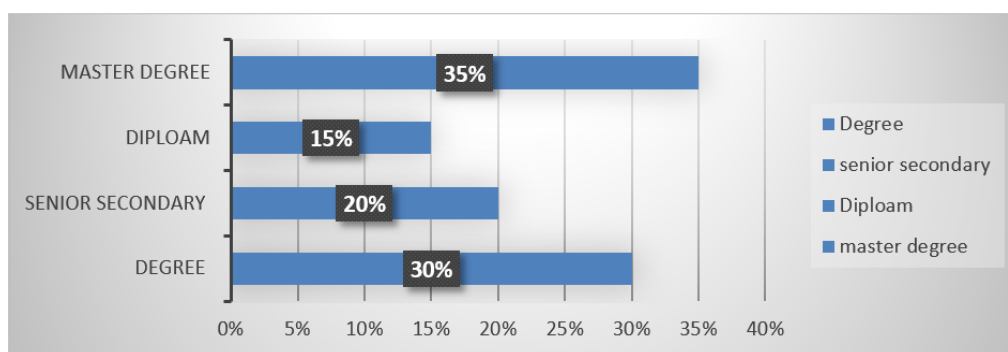

Figure 3. Level of education

The study requested respondent to indicate their education level. 35% of the majority respondent indicated master degree, 30% of the respondent indicated degree, 20% of the respondent indicated senior secondary and 15% of the respondent indicated diploma.
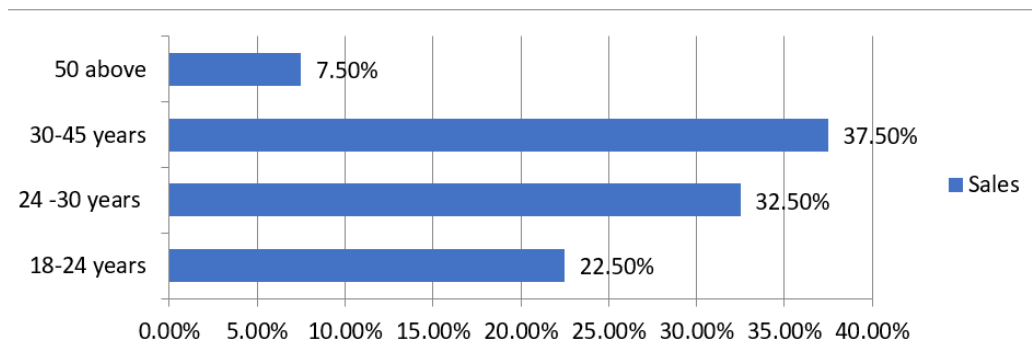

Figure 4. Age

The study requested respondent to indicate their age. 37.5.5% of the majority respondent indicated age between 30 to 45 years, 32.5% of the respondent indicated age between 24 to 30 years, 22.5% of the respondent indicated age between 18 to 24 years and 7.5% of the respondent indicated age above 50 years.

4.2. Effectiveness of project scheduling techniques in mitigating project risks and uncertainties

Table 1. How does the utilization of agile scheduling methodologies impact project completion timelines and overall success?

Valid	Frequency	Percent
Enhances team collaboration and communication	18	45%
Increases project flexibility and adaptability.	16	40%
Reduces project risks and uncertainties	6	15%
Total	40	100%

The study requested respondent to indicate How does the utilization of agile scheduling methodologies impact project completion timelines and overall success. 45% of the majority respondent indicated Enhances team collaboration and communication, 40% of the respondent indicated Increases project flexibility and adaptability and 15% of the respondent indicated Reduces project risks and uncertainties.
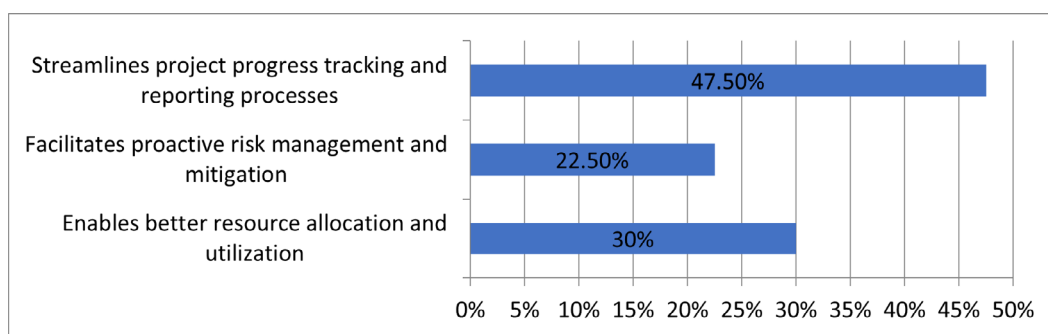

Figure 5. What role does predictive analytics play in optimizing project schedules and improving project outcomes?

The study requested respondent to indicate what role predictive analytics plays in optimizing project schedules and improving project outcomes. 47.5% of the majority respondent indicated streamline project progress tracking and reporting processes, 30% of the respondent indicated facilitates proactive risk management and mitigation and 30% of the respondent indicated enables better resource allocation and utilization.

4.3. Relationship between project scheduling techniques and overall project cost management

Table 2. How does the use of traditional scheduling methods (e.g., Gantt charts) compare to modern techniques (e.g., Critical Path Method) in terms of project completion rates?

Valid	Frequency	Percent
Both methods have comparable project completion rates	10	25%
Modern techniques outperform traditional methods	19	47.5%
Traditional methods outperform modern techniques	11	27.5%
Total	40	100%

The study requested respondent to indicate how does the use of traditional scheduling methods (e.g., Gantt charts) compare to modern techniques (e.g., Critical Path Method) in terms of project completion rates. 47.5% of the majority respondent indicated Modern techniques outperform traditional methods, 27.5% of the respondent indicated Traditional methods outperform modern techniques and 25% of the respondent indicated both methods have comparable project completion rates.

Tables 3. Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig. P	95.0% Confidence Interval for coefficient	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Constant	1.000	0.284		3.521	0.001	0.429	1.571
Project cost management	0.277	0.146	0.263	1.888	0.065	-0.018	0.571

a. Dependent Variable: project scheduling techniques

The coefficients table provides insights into the relationship between project cost management and project scheduling techniques. The constant term in the model is 1.000 with a standard error of 0.284, indicating the baseline value of the dependent variable, project scheduling techniques, when all predictors are at zero. This constant term is statistically significant with a t-value of 3.521 and a p-value of 0.001, suggesting a strong and reliable base effect.

For the predictor variable, project cost management, the unstandardized coefficient is 0.277 with a standard error of 0.146. This coefficient reflects the amount by which the project scheduling techniques are expected to increase for each unit increase in project cost management, assuming all other factors are held constant. The standardized coefficient (Beta) is 0.263, indicating the strength and direction of the relationship between project cost management and project scheduling techniques in standardized terms.

The t-value for project cost management is 1.888, and the p-value is 0.065. Although the p-value is slightly above the conventional threshold of 0.05, suggesting marginal statistical significance, it indicates that the relationship may be approaching significance. The 95% confidence interval for the coefficient ranges from -0.018 to 0.571. This interval includes zero, further suggesting that while there is a positive relationship between project cost management and project scheduling techniques, the effect may not be statistically significant in this sample.

4.4. Challenges faced by project managers in adopting and implementing advanced scheduling methodologies
The study requested respondent to indicate what are the main barriers to integrating advanced scheduling methodologies with existing project management systems. 52.5% of the respondent

Table 4. What are the main barriers to integrating advanced scheduling methodologies with existing project management systems?

Valid	Frequency	Percent
Budget limitations	21	52.5%
Inadequate technological infrastructure	10	25%
Lack of skilled personnel	9	22.5%
Total	40	100%

indicated budget limitations, 25% of the respondent indicated inadequate technological and 22.5% of the respondent indicated lack of skilled personnel.

4.5. Discussion of the findings
4.5.1. Effectiveness of project scheduling techniques in mitigating project risks and uncertainties
The study highlights the profound impact of agile scheduling methodologies and predictive analytics on project management success. Agile methodologies enhance team collaboration (45%) and adaptability (40%), fostering iterative progress and alignment with evolving project goals. They mitigate risks (15%) by promoting real-time adjustments and resolving conflicts early, contributing to timely completions. Predictive analytics further strengthens project outcomes by streamlining progress tracking (47.5%), improving resource allocation (30%), and enabling proactive risk mitigation (30%). External factors like market volatility and regulatory changes (77.5%) demand dynamic scheduling adjustments to maintain timelines and budgets. Stakeholder involvement increases transparency (45%) and

inadequate technology (25%) were key barriers to integration, emphasizing the need for modern systems. The study also highlights regulatory challenges, with 72.5% of respondents noting that industry-specific regulations significantly influence the adoption of advanced scheduling tools. Psychological factors like fear of failure (80%) also hinder adoption, though a desire for recognition motivated 20%. The impact of insufficient training was also clear, with 75% of respondents noting inadequate understanding as a result of poor training. Best practices for implementation include leadership support (55%), comprehensive training (35%), and feedback loops (10%). These findings underline that the successful adoption of advanced scheduling methodologies hinges not only on technological resources but also on organizational culture, leadership, and adequate training.

5. CONCLUSIONS

The study concludes that advanced project scheduling techniques, including agile methodologies, predictive analytics, and modern scheduling software, significantly enhance project risk mitigation and cost management. Agile methods improve team collaboration (45%) and adaptability (40%), fostering timely project completions. Predictive analytics optimizes progress tracking (47.5%) and resource allocation (30%), aiding in proactive risk mitigation. Market volatility and regulatory changes (77.5%) necessitate dynamic scheduling adjustments. The integration of advanced tools enhances data accessibility (37.5%) and process automation. Modern scheduling techniques, like CPM, are preferred by 47.5% of respondents, although traditional methods still serve simpler projects. Efficient resource allocation and stakeholder communication (55%) are key to success. Resource constraints (45%) and budget limitations (52.5%) were identified as significant barriers to adopting advanced methods. Leadership support (55%) and comprehensive training (35%) are crucial for successful implementation. Overall, the study underscores the importance of adaptive scheduling techniques, robust stakeholder engagement, and investment in training and technology to enhance project outcomes and overcome challenge

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