Improving Project Delivery Through Effective Scheduling: An Assessment of Activity Sequencing, Resource Allocation, Critical Path Control, and Schedule Performance

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ABSTRACT

Sound project scheduling decisions are crucial in achieving projects delivered within the stipulated schedule successfully. However, decision deficiencies have been identified as responsible for schedule overruns, poor production utilization, and ultimately, poor project performance. This research evaluated the impact of activity sequencing, resource level-out, schedule control of the critical path, and schedule performance on projects delivered within the stipulated schedule. A systematic scoping review of publication was used for the study. The reviewed literature was thematically integrated from the a priori selected papers on project scheduling, resource constraints, critical path control, uncertainty, construction workflow, digital scheduling, and project control. The findings show that inappropriate activity sequence may lead to construction workflow disruptions and cascaded schedule delays. Also, a poor resource level-out scheme makes it difficult to implement the planning schedule as planned. It was also established that effective critical path control through direct schedule updates requires that change feeds from duration and resource level-out schemes be constantly monitored for effective schedule control since the activities on the critical path can change during project execution. In addition, the research revealed that unpredictable site condition does impact schedule reliability and therefore dynamic, robust, flexible, and adaptable schedule control/management practices are required. BIM, 4D scheduling, and other digital tools can also up project coordination/control if they are properly incorporated into project management. The study concludes that project scheduling should be treated as a static timetable. Improved coordination of activity sequencing, resource allocation, critical path control, uncertainty management, and schedule monitoring can enhance schedule performance and contribute to better project delivery.

Keywords: Project scheduling; activity sequencing; resource allocation; critical path; schedule performance; project delivery; construction management.
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1. INTRODUCTION

Project scheduling structure of the project is an integral part of project management and due to far reaching influences on the role of project scheduling understood as a schedule which offers a structure within time, sequence and interdependence of all tasks is stated to be one of the most vital Project Management (PM) tools in project execution (Baker & Trietsch, 2018; Vanhoucke, 2012). A detailed schedule can support the project manager in applying relationships between activities, setting the respective milestones, distributing limited resources and tracking the project progress to the agreed completion terms (Aliyu, 2012; Ba'Its et al., 2020). Poor scheduling decisions may result in disruptions in workflows, poor resource usage and problems in adhering to planned completion terms (Olivieri et al., 2018; Kannimuthu et al., 2019).

Activity sequencing is crucial as project activities are interconnected which suggests that inappropriate time scheduling of previous activities, as well as delay or inadequacy in preceding activities, could impact on the succeeding ones and consequently the project durations (Baker& Trietsch, 2018, Ba'Its et al., 2020). CPM facilitates the process of defining critical activities that sets the minimum project duration and shift the managerial focus on managing activities that are not flexible or have narrow flexibility (Aliyu, 2012). Nevertheless, controlling the critical-path activities should be done constantly due to frequent alteration of activity durations, resource availability and project conditions that could change the schedule throughout project execution (Vanhoucke, 2012, Demeulemeester & Herroelen, 2011).

Resource scheduling is another major Scheduler. challenge, particularly where several activities compete for limited labour, equipment, materials, or other resources (Lu et al., 2008; Kannimuthu et al., 2019). Resource constraints can make an otherwise technically feasible schedule difficult to implement and may require activities to be rescheduled or performed in alternative sequences (Lu et al., 2008). Poor resource planning can therefore contribute to

interruptions in workflow and negatively affect project time, cost, and quality performance (Kannimuthu et al., 2019; Olivieri et al., 2018).

Project schedules are also exposed to uncertainty arising from changing conditions and variations in activity performance, making schedule robustness an important consideration in project planning (Demeulemeester & Herroelen, 2011). Approaches such as critical chain management, fuzzy critical-path analysis, and dynamic scheduling have been developed to improve the ability of project schedules to accommodate uncertainty and changing project conditions (Araszkiewicz, 2017; Atli & Kahraman, 2012; Vanhoucke, 2012). Similarly, the integration of Building Information Modelling (BIM) and four-dimensional modelling can support construction planning by improving the visualization and coordination of activities and potential conflicts before and during construction (Zhang & Hu, 2011).

In construction projects, ineffective scheduling may therefore extend beyond simple errors in estimating activity durations and may reflect weaknesses in sequencing, resource allocation, critical-path management, and schedule control (Olivieri et al., 2018; Kannimuthu et al., 2019). Effective scheduling requires these elements to be considered collectively because improvements in one aspect may be undermined by weaknesses in another (Demeulemeester & Herroelen, 2011; Baker & Trietsch, 2018). Project scheduling is consequently not only a planning exercise but also an important mechanism for controlling project performance and supporting successful project delivery (Vanhoucke, 2012; Martinsuo, 2013).

2. LITERATURE REVIEW

2.1 Concept of Project Scheduling

Project scheduling is a tool to identify the activities in executing a project, determine the logical relations among activity, estimate the durations of activities and the resources available during a specified project period (Baker& Trietsch,2018; Vanhoucke,2012). Scheduling is a means for project activities to be organized and controlled so as to meet scheduled completion dates (Aliyu, 2012). Scheduling relies on activity information, activity dependence logic, resource availability and the flexibility to meet changes during implementation of the project to a great extent (Demeulemeester & Herroelen,2011; Vanhoucke,2012).

Scheduling is particularly essential in projects where there are a large number of activities that have both technical and temporal dependencies (Ba'Its et al., 2020). An underestimation of the time schedule of an activity might cause delays not only to activities that are directly dependent on it, but also to the entire project duration (Baker & Trietsch, 2018). Hence scheduling should be considered a continuous management process as opposed to a planning activity adopted just at the beginning of the project (Vanhoucke, 2012).

2.2 Activity Sequencing and Dependency Management

The planning of activity sequence, which defines the temporal relationship between the activities and/or the prerequisite condition for the activation of activities (Baker & Trietsch, 2018). The sequence of activities is important because many project operations cannot commence until preceding activities have been completed or sufficiently advanced (Aliyu, 2012). PERT and CPM provide established techniques for representing these relationships and determining the order in which project activities should be considered during scheduling (Ba'Its et al., 2020).

Inappropriate sequencing can create unnecessary waiting periods, workflow interruptions, and delays in activities that depend on earlier operations (Olivieri et al., 2018). Construction scheduling is particularly sensitive to workflow because activities often involve shared work areas, labour, equipment, and materials that must be coordinated over time and location (Olivieri et al., 2018). Location-based management therefore provides an alternative perspective by considering the movement and continuity of work across project locations rather than treating activities only as isolated tasks (Olivieri et al., 2018).

Sequencing decisions can also become more complicated where projects contain multiple activities with different modes of execution or competing objectives (Kannimuthu et al., 2019). In such circumstances, selecting an activity sequence requires consideration of time, cost, quality, and resource requirements rather than duration alone (Kannimuthu et al., 2019). Effective sequencing therefore provides the foundation for establishing a schedule that is both logically achievable and operationally practical (Baker & Trietsch, 2018).

2.3 Critical Path Method and Critical Path Control

The Critical Path Method is a scheduling technique used to identify the sequence of activities that determines the minimum duration of a project (Aliyu, 2012). Activities on the critical path have

little or no available float, meaning that significant delays in these activities can directly affect the planned project completion date (Aliyu, 2012). CPM consequently provides project managers with a means of identifying activities that require close monitoring and timely intervention (Ba'Its et al., 2020).

PERT complements CPM by incorporating activity-duration considerations into project scheduling and can be useful where activity durations are uncertain (Ba'Its et al., 2020). The combination of PERT and CPM can improve schedule development by providing a structured approach to activity relationships and project-duration assessment (Ba'Its et al., 2020). However, critical-path information should not be regarded as permanently fixed because changes in activity durations, resource constraints, and project conditions can cause the critical path to change during execution (Vanhoucke, 2012; Demeulemeester & Herroelen, 2011).

Critical-path control therefore requires regular comparison between planned and actual progress and timely identification of deviations affecting critical activities (Vanhoucke, 2012). Where delays occur on critical activities, corrective actions may be necessary to protect the planned completion date (Aliyu, 2012). The effectiveness of critical-path management is consequently dependent not only on correctly identifying the initial critical path but also on continuously controlling schedule changes during project execution (Vanhoucke, 2012).

2.4 Resource Allocation and Resource-Constrained Scheduling

Resources constitute an important dimension of project scheduling because activities require labour, equipment, materials, finance, and other inputs for their execution (Lu et al., 2008). A schedule may be logically sound but impractical if the resources required to execute its activities are unavailable at the planned time (Lu et al., 2008). Resource-constrained project scheduling therefore considers the limitations imposed by resource availability when determining feasible activity sequences and timings (Lu et al., 2008).

Resource competition becomes more significant when several activities require the same limited resources simultaneously (Lu et al., 2008). Such conflicts may require activities to be delayed, reordered, or assigned alternative execution arrangements, thereby affecting the original project schedule (Kannimuthu et al., 2019). Optimization approaches such as discrete-event simulation and particle swarm optimization have been applied to resource-constrained critical-path analysis to improve scheduling decisions under resource limitations (Lu et al., 2008).

Resource allocation also has implications beyond project duration because different resource decisions can influence project cost and quality (Kannimuthu et al., 2019). Scheduling approaches that consider time, cost, and quality simultaneously can provide a more comprehensive basis for project planning than approaches that focus exclusively on completion time (Kannimuthu et al., 2019). Effective resource allocation therefore requires resources to be matched with activities in a manner that supports both schedule feasibility and overall project objectives (Kannimuthu et al., 2019).

2.5 Dynamic Scheduling and Schedule Performance

Project schedules are subject to changes because actual project conditions may differ from the assumptions made during initial planning (Vanhoucke, 2012). Activity durations may vary, resources may become constrained, and relationships between activities may change as project execution progresses (Demeulemeester & Herroelen, 2011). Dynamic scheduling provides a basis for responding to such changes by allowing project plans and schedules to be adjusted as new information becomes available (Vanhoucke, 2012).

Schedule performance concerns the extent to which actual project progress corresponds with planned activity durations, milestones, and completion dates (Vanhoucke, 2012). Effective performance monitoring enables deviations from the baseline schedule to be identified before they develop into larger project delays (Vanhoucke, 2012). Failure to monitor schedule performance can allow delays in individual activities to accumulate and eventually affect overall project completion (Aliyu, 2012).

The use of scheduling systems that account for actual project dynamics is therefore important for maintaining schedule reliability (Vanhoucke, 2012). Dynamic approaches are particularly relevant where project conditions cannot be fully predicted during initial planning (Demeulemeester & Herroelen, 2011). Schedule performance should consequently be assessed throughout project execution rather than only at project completion (Vanhoucke, 2012).

2.6 Schedule Uncertainty and Robust Project Scheduling

Uncertainty is an inherent feature of project scheduling because activity durations, resource availability, and project conditions cannot always be predicted with complete accuracy (Demeulemeester & Herroelen, 2011). A schedule that performs well under planned conditions

may therefore become ineffective when unexpected changes occur (Demeulemeester & Herroelen, 2011). Robust project scheduling seeks to develop schedules that can withstand such disruptions while limiting their effect on project performance (Demeulemeester & Herroelen, 2011).

Fuzzy critical-path analysis provides another approach for dealing with uncertainty by allowing uncertainty in activity information to be incorporated into critical-path analysis (Atli & Kahraman, 2012). This is relevant where precise activity durations or other scheduling parameters are difficult to establish before project execution (Atli & Kahraman, 2012). Critical-chain management similarly provides a scheduling approach that addresses uncertainty and resource limitations, particularly in environments where several projects compete for shared resources (Araszkiewicz, 2017).

These approaches demonstrate that effective scheduling should account for uncertainty rather than assuming that all planned conditions will remain unchanged throughout project execution (Atli & Kahraman, 2012; Demeulemeester & Herroelen, 2011). Incorporating appropriate protection against uncertainty can improve the ability of a schedule to remain workable when actual conditions differ from initial assumptions (Demeulemeester & Herroelen, 2011).

2.7 Critical Chain and Multi-Project Scheduling

Critical-chain management extends conventional scheduling by giving greater consideration to resource dependencies and uncertainty in project execution (Araszkiewicz, 2017). This approach is particularly relevant in multi-project environments where resources may be shared among several projects and scheduling decisions in one project can affect another (Araszkiewicz, 2017). Resource competition can consequently create scheduling conflicts that cannot be adequately addressed by considering individual project activities in isolation (Araszkiewicz, 2017).

Project portfolio management provides a broader context for understanding these competing priorities because projects within an organization may need to be coordinated according to available resources and strategic priorities (Martinsuo, 2013). Decisions concerning individual project schedules can therefore be influenced by wider portfolio considerations (Martinsuo, 2013). Effective scheduling at project level should consequently recognize situations where resource and managerial constraints originate from a broader collection of projects (Martinsuo, 2013).

2.8 Construction Workflow and Location-Based Scheduling

Construction projects involve activities that are distributed across physical locations and frequently depend on the continuous movement of labour, equipment, and materials (Olivieri et al., 2018). Conventional activity-based schedules may not adequately represent the spatial and workflow relationships that occur during construction (Olivieri et al., 2018). Location-Based Management Systems provide a scheduling perspective that links work activities to specific locations and seeks to improve workflow continuity and resource utilization (Olivieri et al., 2018).

Improved workflow continuity can reduce interruptions and support more efficient use of resources across construction locations (Olivieri et al., 2018). This demonstrates that scheduling effectiveness depends not only on calculating activity dates but also on understanding how planned activities will physically interact during project execution (Olivieri et al., 2018). Consequently, construction scheduling should incorporate both temporal and operational considerations when establishing activity sequences (Olivieri et al., 2018).

2.9 BIM, 4D Scheduling and Construction Coordination

Building Information Modelling and four-dimensional modelling provide technological approaches for integrating construction information with project schedules (Zhang & Hu, 2011). The integration of BIM and 4D models can support the analysis and management of construction conflicts by connecting project components with their planned construction sequence (Zhang & Hu, 2011). This can improve the visualization of construction processes and assist managers in identifying potential problems before they disrupt execution (Zhang & Hu, 2011).

The application of BIM and 4D scheduling is particularly relevant to effective activity sequencing because construction operations can be examined in relation to both physical components and time (Zhang & Hu, 2011). Such integration can support better coordination of construction activities and contribute to improved management of structural safety and conflicts during construction (Zhang & Hu, 2011).

2.10 Relationship Between Scheduling Weaknesses and Poor Project Delivery

The literature indicates that project delays can emerge from interconnected weaknesses rather than from a single scheduling failure (Baker & Trietsch, 2018; Demeulemeester & Herroelen, 2011). Poor activity sequencing can interrupt workflow, inadequate resource allocation can make planned activities infeasible, and weak critical-path control can allow delays in critical activities to affect

project completion (Aliyu, 2012; Lu et al., 2008; Olivieri et al., 2018). These weaknesses can interact and amplify one another during project execution (Kannimuthu et al., 2019; Vanhoucke, 2012).

The literature further suggests that project scheduling should integrate activity logic, resource constraints, uncertainty, monitoring, and coordination rather than treating each component independently (Demeulemeester & Herroelen, 2011; Kannimuthu et al., 2019). Robust and dynamic scheduling approaches can help project teams respond to deviations, while CPM, PERT, critical-chain techniques, and location-based approaches provide different mechanisms for improving schedule planning and control (Ba'Its et al., 2020; Araszkiewicz, 2017; Olivieri et al., 2018).

Technology and institutional management can also influence the effectiveness of project planning and control. Digital approaches can support information management and coordination, while effective institutional systems emphasize transparency, discipline, risk management, and appropriate allocation of limited resources (Adenike, 2021; Adenike, 2022; Adenike, 2017). These principles provide a broader management context for understanding why scheduling decisions must be supported by reliable information, disciplined implementation, and effective resource control (Adenike, 2017; Adenike, 2021).

2.11 Financial Resources, Fiscal Discipline and Project Scheduling

The access to and adequate control of financial resources 1 become an important issue in project scheduling decision as the scheduling decisions should be reinforced by resources that are available to be mobilized at the time required (Adenike, 2017). Poor liquidity or weakness in terms of financial resources allocation may impede the realization of scheduled project activities, and even activities may have to be moved in time or have its date changed (Adenike, 2017). This adds support to the statement that resource-constrained scheduling should take into account the financial circumstances that sustain project activities (Lu et al., 2008; Kannimuthu et al., 2019).

Financial discipline can directly affect the trustworthiness of project implementation through the notion of maintaining the organization of the activities planned through the dispensation of the resources made available by the money saved away with the effective control (Adenike, 2021) of the fund management. The concepts of transparency and financial discipline in the Treasury Single Account project implementation can also be related to project delivery as a

way to align financial planning with the scheduling activities, thus maintaining a stable flow of resources to activities scheduled for implementation. are appropriately planned and controlled (Adenike, 2021).

Risk and liquidity considerations are particularly relevant where project activities depend on timely financial commitments (Adenike, 2017). A schedule may therefore be technically feasible but difficult to implement when financial resources are not available at the required time (Lu et al., 2008; Adenike, 2017). Integrating financial resource considerations with conventional scheduling can consequently strengthen the practicality of project plans and reduce disruptions associated with resource shortages (Kannimuthu et al., 2019).

2.12 Digital Transformation, Technology Adoption and Project Scheduling

The increasing use of digital technologies has created opportunities for improving the way information is generated, communicated, and used in management decisions (Adenike, 2022). In project scheduling, reliable and timely information is important because managers require accurate information on activity progress, resource availability, and changing project conditions to make appropriate scheduling decisions (Vanhoucke, 2012). Digital technologies can therefore support more responsive approaches to scheduling where project information needs to be updated as conditions change (Adenike, 2022; Vanhoucke, 2012).

Technology adoption, however, can be affected by institutional, operational, and user-related challenges (Adenike, 2022). This is relevant to construction scheduling because the availability of digital scheduling tools does not automatically guarantee improved project performance if project teams lack the capacity or organizational systems required to use them effectively (Zhang & Hu, 2011; Adenike, 2022). Effective implementation therefore requires appropriate processes, information management, and organizational support alongside the technological tools themselves (Adenike, 2022).

The relevance of digital transformation is also evident in the application of BIM and 4D modelling to construction scheduling. BIM-based approaches allow project information to be connected with time and construction activities, thereby supporting conflict analysis, coordination, and schedule management (Zhang & Hu, 2011). The broader experience of digital technology adoption similarly indicates that the benefits of technological systems depend on how effectively they are integrated into existing management practices (Adenike, 2022).

At a broader organizational level, project portfolio management emphasizes the need to coordinate individual projects within wider organizational priorities and resource constraints (Martinsuo, 2013). Financial risk and liquidity considerations can similarly affect the ability to maintain planned project activities, while financial transparency and discipline provide a basis for better resource control (Adenike, 2017; Adenike, 2021). Technology adoption can strengthen information-based decision-making, although its effectiveness depends on the ability of organizations to integrate digital systems into their management processes (Adenike, 2022).

3. METHODOLOGY

The study took a structured literature review to evaluate the impact of project scheduling decision on project delivery with focus on activity sequencing, resource allocation, control of critical path, uncertainty and performance of schedule (Baker & Trietsch, 2018; Vanhoucke, 2012). This approach is used as a means of gathering existing knowledge on project scheduling and to determine how scheduling deficiencies may lead to slippage and sub-optimally of project (Demeulemeester & Herroelen, 2011; Kannimutheu et al, 2019).

The review utilized only the 15 referencing entries that were provided for this study, which only had 14 different references, as seemingly; Demeulemeester and Herroelen (2011) had two references to the authors in the referencing list. These diverse references dealt on the following broad issues: project scheduling, CPM and PERT (Aliyu, 2012; Lu et al., 2008), resource constrained project scheduling (Ba'Its et al., 2020; Zhang & Hu, 2011), robust scheduling (Martinsuo, 2013), construction flow (Demeulemeester & Herroelen, 2011), the critical-chain approach (Adenike, 2017, 2021, 2022) BIM and 4D modelling. project portfolio management, financial resources management, fiscal discipline and adoption of modern technology (Aliyu, 2012; Ba'Its et al., 2020; Lu et al., 2008; Zhang & Hu, 2011)

The literature was reviewed by a thematic synthesis. The following studies were examined according to their principal contribution to project scheduling and project delivery. The identified evidence was then grouped into five major analytical themes: activity sequencing, resource allocation, critical path control, schedule uncertainty and robustness, and schedule performance (Baker & Trietsch, 2018; Demeulemeester & Herroelen, 2011; Vanhoucke, 2012). Additional themes concerning financial resources, digital technology, construction workflow, and portfolio-

level management were incorporated to provide the broader context within which scheduling decisions are implemented (Adenike, 2017; Adenike, 2021; Adenike, 2022; Olivieri et al., 2018; Martinsuo, 2013).

The review specifically examined the relationship between scheduling weaknesses and project delays by comparing findings across the selected studies. Particular attention was given to situations in which incorrect activity sequencing, resource conflicts, changes in critical activities, uncertainty, or ineffective monitoring could disrupt planned project execution (Lu et al., 2008; Aliyu, 2012; Vanhoucke, 2012). The review also considered scheduling approaches proposed to improve project performance, including CPM, PERT, resource-constrained scheduling, critical-chain management, robust scheduling, location-based management, and BIM-supported 4D scheduling (Ba'Its et al., 2020; Araszkiewicz, 2017; Demeulemeester & Herroelen, 2011; Olivieri et al., 2018; Zhang & Hu, 2011).

The findings from the literature were synthesized qualitatively rather than statistically because the selected studies employed different methods, contexts, objectives, and scheduling approaches (Atli & Kahraman, 2012; Kannimuthu et al., 2019). This approach enabled the study to identify common scheduling problems and the mechanisms through which they may affect project delivery while drawing on the complementary perspectives presented across the selected literature (Martinsuo, 2013; Adenike, 2022).

4. RESULTS AND DISCUSSION

The synthesis of the reviewed literature shows that project delivery is strongly influenced by the quality of scheduling decisions made before and during project execution. Across the reviewed studies, four major scheduling dimensions emerged as particularly important: activity sequencing, resource allocation, critical path control, and schedule monitoring and adaptation (Aliyu, 2012; Baker & Trietsch, 2018; Vanhoucke, 2012). The literature also indicates that these dimensions are interconnected, meaning that weaknesses in one area can generate problems in the others (Demeulemeester & Herroelen, 2011; Kannimuthu et al., 2019).

Table 1. Major scheduling weaknesses and their implications for project delivery

Scheduling weakness	Immediate effect	Potential project-delivery consequence	Supporting studies
Poor activity sequencing	Workflow interruption	Activity and project delays	Baker & Trietsch (2018); Olivieri et al. (2018)
Inadequate resource allocation	Resource conflicts and idle periods	Delayed activities and increased project duration	Lu et al. (2008); Kannimuthu et al. (2019)
Weak critical-path control	Delays in critical activities remain undetected	Extension of project completion time	Aliyu (2012); Ba'Its et al. (2020)
Failure to account for uncertainty	Schedule becomes vulnerable to disruption	Reduced schedule reliability	Demeulemeester & Herroelen (2011); Atli & Kahraman (2012)
Poor schedule monitoring	Deviations are identified late	Limited opportunity for corrective action	Vanhoucke (2012)
Poor construction workflow coordination	Interrupted movement of work and resources	Reduced productivity and delays	Olivieri et al. (2018)
Inadequate digital coordination	Conflicts may remain unidentified	Rework and schedule disruption	Zhang & Hu (2011)

4.1 Activity Sequencing and Project Delays

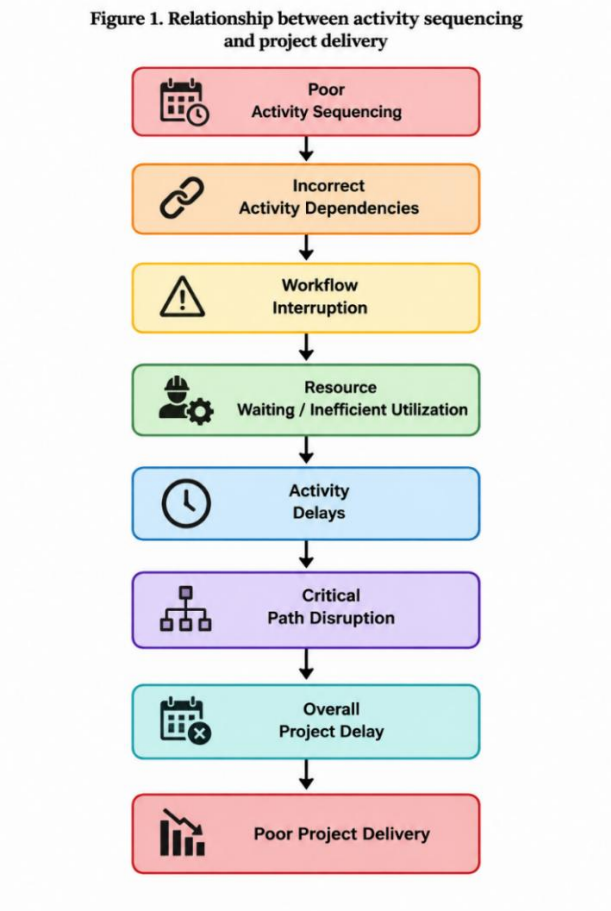
The review indicates that appropriate activity sequencing is fundamental to maintaining a continuous project workflow. Activities with logical dependencies must be arranged so that preceding tasks are sufficiently completed before dependent activities commence (Baker &

Trietsch, 2018; Ba'Its et al., 2020). Poor sequencing can result in unnecessary waiting periods, interruptions, and inefficient use of project resources (Olivieri et al., 2018).

CPM and PERT provide structured mechanisms for establishing activity relationships and determining project duration (Aliyu, 2012; Ba'Its et al., 2020). However, the effectiveness of these techniques depends on the accuracy of the underlying activity relationships and duration estimates (Baker & Trietsch, 2018). Dynamic changes during project execution can also alter the original sequence and require schedules to be updated (Vanhoucke, 2012).

The relationship between sequencing and project delivery can therefore be represented as a chain in which poor sequencing creates workflow interruptions, which subsequently affect resource utilization and activity completion.

Figure 1. Relationship between activity sequencing and project delivery



The evidence from location-based management further suggests that sequencing should consider the physical movement and continuity of work across project locations (Olivieri et al., 2018). This

is particularly important in construction projects where different activities may compete for the same work areas or resources (Olivieri et al., 2018).

4.2 Resource Allocation and Schedule Performance

Resource allocation emerged as another major determinant of schedule performance. A planned sequence of activities cannot be effectively implemented when the labour, equipment, materials, or other resources required for execution are unavailable (Lu et al., 2008). Resource-constrained scheduling therefore seeks to develop schedules that remain feasible within available resource limits (Lu et al., 2008).

The literature indicates that resource allocation affects not only project duration but also cost and quality performance (Kannimuthu et al., 2019). When several activities require the same limited resources, project managers may have to alter the original schedule or prioritize particular activities (Lu et al., 2008). Optimization techniques can assist in identifying more effective combinations of activities and resource assignments (Lu et al., 2008).

Financial resources also form part of this broader resource-management problem. Risk and liquidity considerations can affect the ability of organizations to provide resources when required, while effective financial discipline supports the continuity of planned activities (Adenike, 2017; Adenike, 2021). Consequently, scheduling decisions should be supported by realistic consideration of the financial resources necessary to sustain project activities (Adenike, 2017).

4.3 Critical Path Control

The reviewed studies confirm that CPM remains an important instrument for identifying activities that have a direct influence on project duration (Aliyu, 2012; Ba'Its et al., 2020). Delays affecting critical activities can extend the overall project completion date because these activities have limited scheduling flexibility (Aliyu, 2012).

However, the critical path should not be treated as permanently fixed. Changes in activity durations, resource availability, and project conditions can cause the critical path to change during project execution (Vanhoucke, 2012; Demeulemeester & Herroelen, 2011). Effective critical-path control therefore requires continuous monitoring and timely intervention rather than reliance on the original baseline schedule (Vanhoucke, 2012).

The literature also indicates that uncertainty can reduce the reliability of conventional critical-path analysis (Atli & Kahraman, 2012). Robust scheduling and fuzzy approaches provide alternative mechanisms for dealing with uncertain activity conditions and improving schedule resilience (Demeulemeester & Herroelen, 2011; Atli & Kahraman, 2012).

4.4 Integrated Scheduling and Project Delivery

The evidence indicates that the four major dimensions examined in this study are closely interconnected. Activity sequencing determines when work should occur, resource allocation determines whether the planned work can be executed, critical-path control identifies activities requiring priority attention, and schedule monitoring enables managers to respond to deviations (Baker & Trietsch, 2018; Aliyu, 2012; Lu et al., 2008; Vanhoucke, 2012).

Table 2. Scheduling practices for improving project delivery

Scheduling dimension	Effective practice	Expected improvement
Activity sequencing	Establish logical dependencies and feasible activity relationships	Smoother workflow and fewer activity conflicts
Resource allocation	Match resource availability with scheduled activities	Reduced idle time and resource conflicts
Critical path control	Continuously monitor critical activities	Faster identification and correction of delays
Schedule monitoring	Compare actual progress with planned performance	Earlier corrective action
Construction coordination	Apply location-based scheduling	Improved workflow and resource utilization
Digital coordination	Integrate BIM and 4D scheduling	Better visualization and conflict identification

Financial planning	Align project schedules with available financial resources	Greater continuity of project execution

The integration of BIM and 4D modelling can further strengthen this process by connecting project components with planned construction activities and helping identify conflicts before they disrupt execution (Zhang & Hu, 2011). Location-based management similarly improves the coordination of workflow and resource usage in construction environments (Olivieri et al., 2018).

At the organizational level, project portfolio management demonstrates that scheduling decisions may also be affected by competing projects and organizational priorities (Martinsuo, 2013). Financial management considerations reinforce the importance of ensuring that resources required by schedules are available and properly controlled (Adenike, 2017; Adenike, 2021). Furthermore, digital technology can improve information-based decision-making, although successful adoption depends on appropriate organizational and operational support (Adenike, 2022).

Overall, the results demonstrate that poor scheduling is not simply a problem of incorrect dates on a project programme. It can originate from weak activity sequencing, unrealistic resource assumptions, inadequate critical-path monitoring, failure to accommodate uncertainty, poor workflow coordination, and insufficient information for decision-making (Baker & Trietsch, 2018; Demeulemeester & Herroelen, 2011; Olivieri et al., 2018). Effective scheduling therefore requires an integrated approach that combines logical sequencing, resource optimization, critical-path control, continuous monitoring, and adaptive management to improve the likelihood of completing projects within planned time, cost, and quality objectives (Kannimuthu et al., 2019; Vanhoucke, 2012).

The integrated relationship among these scheduling factors is illustrated below.

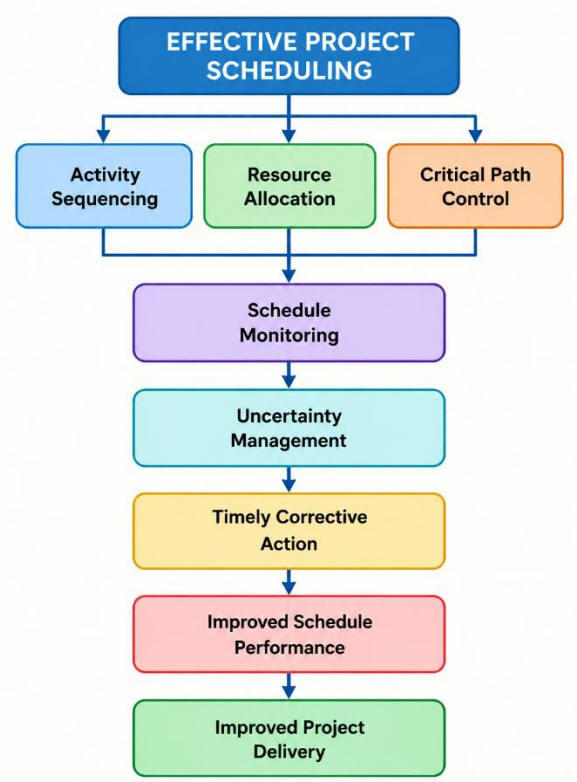


Figure 2. Integrated Framework for Effective Project Scheduling and Improved Project Delivery

5. DISCUSSION

Overall, the present research shows that quality scheduling decisions are strongly correlated with successful project delivery. The literature shows that, rather than an activity planning exercise, scheduling tasks represent a collective process of activity sequencing, resource allocation, critical-path management, dealing with uncertainty and project performance observation (Baker & Trietsch, 2018; Vanhoucke, 2012; Demeulemeester & Herroelen, 2011).

5.1 Activity Sequencing and Project Performance

As previously argued the results show that a poor activity sequence is a key contributor to project delay. If activities are not sequenced according to their logical dependencies, plan delays can be caused within the network when subsequent activities cannot start on plan leading to workflow interruptions and project duration overrun (Baker & Trietsch, 2018; Ba'Its, et al., 2020). These

findings concur with the Olivieri et al.'s (2018) construction workflow argument that continuous workflow must be kept up during construction.

Therefore, who plan activities sequences should do it considering not only the durations estimates, but also the technical and operational relationships among activities (Baker & Trietsch, 2018). For construction projects, the location of work activities, access, movement of resources and the interaction between trades and activities should be taken into account (Olivieri et al., 2018). Consequently, scheduling decisions that appear reasonable from a purely time-based perspective may produce poor outcomes when their operational implications are ignored (Olivieri et al., 2018).

5.2 Resource Allocation as a Determinant of Schedule Performance

The findings further demonstrate that a schedule can only be achieved when the resources required for scheduled activities are available at the appropriate time (Lu et al., 2008). Resource conflicts may force project managers to change activity sequences or postpone activities, thereby creating deviations from the baseline schedule (Lu et al., 2008). This supports the argument by Kannimuthu et al. (2019) that project scheduling should consider time, cost, and quality simultaneously rather than treating project duration as the only scheduling objective.

Financial resources are also relevant to this relationship because inadequate liquidity can affect the ability to sustain planned project activities (Adenike, 2017). Effective financial control and discipline can therefore support the continuity of project execution by ensuring that available resources are properly managed (Adenike, 2021). The implication is that resource allocation within project scheduling should include realistic consideration of the financial capacity required to support planned activities.

5.3 Critical Path Control and Delay Prevention

The findings confirm the continuing relevance of CPM and PERT for project schedule development and control (Aliyu, 2012; Ba'Its et al., 2020). Identifying critical activities allows managers to concentrate monitoring and corrective actions on activities with the greatest potential to influence project completion (Aliyu, 2012). However, the results also show that critical-path control should be dynamic because changes in activity durations and resource availability can modify the critical path during execution (Vanhoucke, 2012).

This suggests that simply identifying the critical path at the beginning of a project is insufficient. Project managers need to continually compare actual performance with planned performance and reassess scheduling priorities when significant deviations occur (Vanhoucke, 2012). Robust scheduling is particularly relevant in this regard because it seeks to reduce the vulnerability of project schedules to disruptions and uncertainty (Demeulemeester & Herroelen, 2011).

5.4 Role of Digital Tools in Scheduling

The findings indicate that digital technologies can strengthen scheduling and project coordination when appropriately implemented. BIM and 4D-based approaches can connect construction activities with project components and time, thereby improving the visualization of planned work and identification of potential conflicts (Zhang & Hu, 2011). This can complement conventional scheduling techniques by providing project teams with a more integrated representation of construction activities (Zhang & Hu, 2011).

However, technology alone does not guarantee better scheduling outcomes. The broader evidence on technology adoption indicates that institutional and operational challenges can affect the effectiveness of digital systems (Adenike, 2022). Consequently, digital scheduling tools need to be supported by appropriate management processes, competent users, reliable information, and organizational readiness (Adenike, 2022).

5.5 Implications for Integrated Project Scheduling

The combined findings suggest that the strongest approach to project scheduling is one that integrates activity sequencing, resource allocation, critical-path control, uncertainty management, and schedule monitoring (Baker & Trietsch, 2018; Demeulemeester & Herroelen, 2011). These elements should not be treated as independent scheduling activities because weaknesses in one dimension can undermine performance in another (Kannimuthu et al., 2019).

The findings are also relevant at the organizational level because projects may compete for shared resources and managerial attention within a wider portfolio (Martinsuo, 2013). Scheduling decisions should therefore consider not only individual project requirements but also wider resource and organizational priorities (Martinsuo, 2013). Financial discipline, appropriate resource

allocation, and effective information management further strengthen the conditions necessary for successful schedule implementation (Adenike, 2017; Adenike, 2021; Adenike, 2022).

6. CONCLUSION

An effective project scheduling is critical to successful project delivery as it is the foundation for: (1) arranging of activities; (2) allocation of resources; (3) controlling of critical activities; and (4) monitoring of project progress. The review identified that the inaccuracies of scheduling decisions may play a dominant role to project time delay and under performance where activities are poorly sequenced, resources inadequately allocated, critical activities uncontrolled, and any change in project circumstance ignored.

Additional findings from the study show that activity sequence and resource allocation are tightly coupled with schedule reliability. The plan might be technically correct, but it can still fail if the necessary resources for planned activities are not available at the right time. Likewise, the identification of the critical path is not enough because during the execution of the project the activities on the critical path may change and generate new causes of delay.

Another key conclusion is that project schedules must be flexible enough to accommodate uncertainty. A fixed schedule, even if initially achievable, may become meaningless if conditions change. Ongoing control, prompt rectification, and adjustment of activity dependencies and resource allocations during project performance therefore are needed.

Furthermore, the research explores the conditions under which digital methods can be used to improve scheduling and builds the argument that they can indeed incorporated into project management. Technology should complement rather than replace effective planning, competent decision-making, resource control, and continuous monitoring.

Overall, improving project delivery requires a shift from viewing scheduling as a static programme to treating it as a continuous, integrated, and adaptive management process. Effective coordination of activity sequencing, resource allocation, critical path control, uncertainty management, and schedule monitoring can improve schedule performance and increase the likelihood of completing projects within their planned objectives.

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