Managing Multiple Projects: A Literature Review of Setting Priorities and a Pilot Survey of Healthcare Researchers in an Academic Setting

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Abstract

Objectives

To summarize and then assess with a pilot study the use of published best practice recommendations for priority setting during management of multiple healthcare research projects, in a resource-constrained environment.

Methods

Medical, economic, business, and operations literature was reviewed to summarize and develop a survey to assess best practices for managing multiple projects. Fifteen senior healthcare research project managers, directors, and faculty at an urban academic institution were surveyed to determine most commonly used priority rules, ranking of rules, characteristics of their projects, and availability of resources. Survey results were compared to literature recommendations to determine use of best practices.

Results

Seven priority-setting rules were identified for managing multiple projects. Recommendations on assigning priorities by project characteristics are presented. In the pilot study, a large majority of survey respondents follow best practice recommendations identified in the research literature. However, priority rules such as Most Total Successors (MTS) and Resource Scheduling Method (RSM) were used "very often" by half of the respondents when better performing priority rules were available.

Conclusions

Through experience, project managers learn to manage multiple projects under resource constraints. Best practice literature can assist project managers in priority setting by recommending the most appropriate priority given resource constraints and project characteristics. There is room for improvement in managing multiple projects.

Introduction

Projects are limited in quality by three factors: resources, time, and scope. By optimizing both human and financial resources under a fixed duration, a project manager can maintain or increase the scope and quality of a project. More often, with a fixed scope and duration, effective project management seeks to maintain quality by optimizing resources. Frequently, the availability of resources assigned to a project is limited and not sufficient to accomplish all the required activities, without compromising quality.[1]

In a survey of 176 private and public companies in Canada in 1997, 61 percent of respondents reported project failures. Of the failed projects, more than three-quarters exceeded schedules by 30 percent or more, and more than half exceeded their budgets by a substantial margin. The primary cause of project failure was poor project planning, and projects failed more often because of scheduling overruns than budget overruns. In these situations, project managers who do not optimize resources will reduce the quality of the project or cause delays in activity completion. In a survey of 365 American companies in 1995, only 16 percent of projects were completed on time, on budget, and within specifications.[2] On average, completed projects were 74 percent of the content of the original scope.

Since this annual survey began in 1995, there have been some improvements in project performance such as decreasing failures by 15 percent in 2004. Cost overruns have been reduced for challenged projects from 180 percent to 43 percent in 2004. Still CHAOS estimates that United States project waste accounts for $38 billion in lost dollar value and $17 billion in cost overruns.[3]

The benefits to working in an environment with multiple projects include increased learning opportunities and a rich work environment. However, a large number of projects have scarce time resources and inadequate routines, and project overload leads to a lack of recuperation and missed deadlines.[4]

Considering restricted per-period availabilities of multiple resource types, a project must be finished as early as possible without wasting resources that project managers could use more efficiently elsewhere. Compounding the problem, companies manage various projects simultaneously, sharing a pool of renewable resources.

Managing Multiple Projects

Managing multiple projects has been termed the resource-constrained multiple-project scheduling problem (RCMPSP).[5] Managing this RCMPSP can be accomplished by exact procedures, metaheuristics, or simple priority rules. For real-world problems with a large number of jobs, optimizing a resource and cost schedule using exact procedures such as dynamic programming, or metaheuristic techniques such as search algorithms are computationally difficult, time-consuming, expensive, and unnecessary.[6] Instead construction companies, urban maintenance schedules, auditors, and software design companies have used simple heuristic (rules-of-thumb) priority rules to establish priorities for resources.

The advantage of using priority rules for managing resources is that the rules are straightforward, which makes them easy to implement. They are also the most commonly used methods in experimental literature to simulate ideal scheduling of scarce resources for multiple projects. Also, most commercial scheduling software programs rely on these priority rules.[7]

To implement simple priority rules, a framework of a scheduling scheme must be present. This framework includes using parallel, bidirectional, dynamic, and global planning. With the appropriate scheduling scheme, priority rule setting is as effective as exact procedures and metaheuristics in managing resources.[8-11]

Healthcare research is unique. If the projects are simply repetitive in nature, managers can use the Projects in Controlled Environments (PRINCE) model for routine research supervision.[12] However, healthcare research projects are not repetitive. In contrast, software engineering projects have a client that has set detailed specifications for the project, and there are ongoing communications and managed expectations. Healthcare research, especially academic health services research, has a broad scope and the

details cannot be defined at the start of the project, making planning an ongoing process. In addition, the topic is usually a one-time subject for academic researchers who have received a grant that may be used to hire new staff and form new collaborations. With a new team, considerable effort must be put into early planning and early learning resulting in early schedule slippage, which is the greatest early warning sign for project failures.[13]

When early schedule slippage occurs, there is no chance of project overruns because the grant value has been specified. Projects then are compromised in quality by poor planning and have little advantage for catching up. There is also limited streamlining with nonrepetitive tasks that require judgment.[14] Continual judgment demands cause further delays. With multiple projects flexibility in planning has been shown to be desirable, but flexibility in execution is undesirable.[15] Thus, healthcare research requires ongoing planning and execution of nonrepetitive activities or decisions, since delays in planning contribute significantly to project failure.

The purpose of this paper is to investigate the effectiveness of management of multiple projects in healthcare research. This was achieved by first reviewing and summarizing the literature to identify best practices for managing multiple projects, second by using best evidence to create a survey, and third by using the survey to identify current practices for project management of faculty, directors, and research managers. Finally, team members compared actual management priority setting practices versus best practice. Further, we present recommendations for setting priorities in the management of multiple projects in healthcare research when resources are constrained.

Methods

Literature Search

The electronic databases searched included International Abstracts in Operational Research, EconLit, ABI/INFORM Global, ProQuest Nursing & Allied Health, Business Source Complete (Limited to Project Management and Academic Journals), Management & Organization Studies: A SAGE Full-Text Collection, and OVID (Medline, Embase, CINAHL). Literature was searched for managing multiple projects in healthcare research, assignment of priority rules when managing projects in healthcare research, implementation of simple priority rules in manufacturing/operations setting. Key words used included project planning, multiple projects, priority rules, and RCMPSP. The most common priority rules and the situations in which they performed best were identified.

Survey

Despite the abundance of priority rules, no previous instrument to assess priority rules was available. The survey was developed and pretested on a group similar to the target population. Comments lead to revisions of the survey instrument.

The finalized survey was sent by e-mail to a small convenient sample of healthcare researchers, including department heads, managers, directors, and faculty and experienced project managers within an urban academic institution. From the nature of the institution, all were involved in clinical and health services research. This group was selected because they were senior staff and faculty who had success in project management, and in most cases had no formal training in project management such as the citation Project Management Professional (PMP) designation, or had an MBA or equivalent advanced degree in management.[16]

The survey instrument was divided into three parts. In part A, respondents were asked how often they used each of most common priority rules. They were allowed to classify their response by “Always,” “Very Often,” “Sometimes,” “Rarely,” “Never,” and “Not Applicable.” In part B, we asked the respondents to rank the three most common priority rules, from first to second to third choice. In Part C, we asked for details on how many projects they currently manage, the average project duration, the shortest and longest project, and the number of staff they have in each project. (See Appendix I for the complete survey). The choice of top three priority rules were compared to project characteristics.

Results

Literature Review

A total of 278 references were found that dealt with multiple projects (January 23, 2007). No direct evidence of the use of setting priorities was found regarding managing multiple projects in healthcare research, nor on the implementation of simple priority rules in manufacturing/operations setting. The literature located on priority rules or RCMPSP provides surveys on types and number of resource constraints, and the activity and project characteristics. These surveys provide inputs for the more substantial published literature that provides evidence on optimal priority rules in computer simulations. Several papers reported on managing projects in healthcare research and several articles discussed project management in healthcare research.

Common Priority Rules

A review of the literature identified seven priority rules that had robust superiority in achieving due date and efficient resource management (see Table 1). The following is a description of these seven most effective priority rules described in the research literature that were included in the survey instrument. The first priority rule identified First Come First Served (FCFS), where the first eligible activity is assigned the highest priority. This procedure is representative of scheduling heuristics found in many dynamic scheduling environments. In FCFS, activities are not screened by work content or due date. The project manager gives priority to the earliest arrived activity. In particular, the project manager will not begin a new activity until the current activity is completed. This could be called the simple checklist method. A manager adds items to a list of activities to perform, and then assigns items at the top of the list regardless of activity characteristics.

Similar to FCFS is the Shortest Activity for the Shortest Project (SASP), which gives precedence based on the minimum of the sum of project duration and activity time. Here the length of the project is considered as well as the length of the activity. SASP could be answering daily e-mail, while activities that have a longer duration are set aside until the person completes the little things. This could be called the modified checklist method. A manager adds items to a list of activities to perform, and then assigns items that are feasible in a short period of time with preference for short projects.

An opposite of SASP is Maximum Total Work content (MAXTWK). This simple priority rule looks at the activities that require the most resources and the manager assigns these the highest priority. The manager assumes that the little tasks that take small amounts of resources and time will be completed in parallel with the larger tasks.

Similar to MAXTWK is the Resource Scheduling Method (RSM). Under this priority rule, the manager assigns resources to activities that would increase the project duration if resources were inadequate. The process has two steps. In the first step, the project manager determines the timeline of the project and then identifies the sequence of critical activities. In the second step, the project manager reviews the ability to perform activities subject to the resource constraints, and then adjusts the schedule of activities subject to these resource constraints. The goal is to minimize project duration. By using the two-step approach, this method assigns priorities to activities that are time sensitive subject to resources. This method is most effective in construction-industry projects.

One priority rule that looks at activities in the overall project flow is Most Total Successors (MTS). MTS assigns priority to the activities with the largest number of successor activities that require completion before another activity can begin. For two similar projects, the priority is given to the project with the most number of activities remaining. This rule ignores the time constraint of a due date and resource constraints, and is most efficient when two similar competing projects begin at the same time and have the same due date.

A number of rules are based strictly on time constraints. These include Latest Start Time (LST), Latest Finish Time (LFT), and Minimum Slack (MINSLK). MINSLK is equivalent to the Min LST rule and was not included in the survey instrument. The LST is the latest an activity can start and not extend

the overall project duration. In contrast, the Earliest Start Time (EST) is the earliest possible time (usually in days into the project) that an activity can be started. Slack is the difference in the EST and LST. Difference between EST and Early Finish Time (EFT) is the duration of the activity. Similarly, the difference between LST and Late Finish Time (LFT) is also the activity duration (see Figure 1).

Recommendations

The evidence that has accumulated based on computer simulations is provided here in terms of increasing complexity. Most research builds on earlier research by tightening constraints, by adding more types of constraints, or by increasing the complexity of projects. The evidence with literature recommendations is summarized in Table 1. A recent technical review of heuristics is available.[17, 18]

Listed in Table 2 are the recommendations for assigning priority based on the literature. For short simple tasks, SASP is recommended.[19-21] When tasks arrive randomly, FCFS works best.[22, 23] When resource demand is high, giving priority to activities by MAXTWK is best.[24, 25] With very complex problems, Min LFT is best.[26-29] In all other cases that include medium to longer tasks, low to medium complexity, possibility of reworks, and where learning is possible, Min LST is best.[30-33] RSM and MTS are best for a static project environment, where all projects start at a certain date.

In summary of the recommendations, a project manager should first assess the project environment.

- If projects or activities arrive randomly, they should be dealt with first come, first served and as soon as possible.
- If tasks are simple and short and there is time available to complete the simple tasks then these tasks should be given priority.

The project manager should be aware of the particular characteristics of activities for each project.

- Large work requirements should be given priority by size of workload.
- Complex problems and activities requiring a high degree of collaboration should be scheduled with the due date in mind.
- When there is a high probability of error or rework, or if there are conditions of learning, these critical activities should be prioritized by whichever activity can begin first.

Survey Results

Out of 15 surveys that were sent electronically, 10 (66 percent) were returned (Table 2). Table 3 provides the project characteristics data on projects currently being managed. The table is sorted by declining number of projects managed. The mean number of projects managed was 10.4, although respondents 1 through 4 who managed 25, 20, 17, and 15 projects, respectively, skewed this. The mean project duration was 1.8 years. The mean number of staff per project was 3.1 with a spread of 1.5 to 12, and most projects were staffed by one to three people.

No subject answered “Not Applicable” for any priority rule. FCFS was very symmetric in that most used this priority rule “Sometimes.” Respondents most commonly used priority rules LFT, MAXTWK, MTS, and RSM “Very Often,” while LST, FCFS, and SASP were used “Sometimes.” Two respondents “Always” use LFT and one “Always” uses LST and MAXTWK. “Never” responses were given for FCFS (one), LSFT (two), LST (two), MAXTWK (one), and SASP (one).

The choice of priority depends on the number and types of projects that are under management (Table 3). If we divide the project characteristics into top five by number of projects, there is a difference in choice of priority rules. With more projects, priorities are set more by workload (MAXTWK: 4 out of 5 will be in the top 5 while 2 out of 5 where in the lower 5 number of projects) and less by due date (LFT: top 5 2/5 l bottom 5 4/5). For increased number of projects, assigning priority by workload (MAXTWK) is appropriate if there is variability in work content. Assigning priority by due date (LFT) is more appropriate when there are complex projects. From this, we can interpret that if the managers are

assigning appropriately, they believe that with more projects, the projects vary in workload and not in complexity.

If we divide the project characteristics into top five by project duration, there is a difference in choice of priority rules. With increased project duration, priorities are assigned more often by due dates (LFT: top 5/5; bottom 5 2/5) and less by workload (MAXTWK: top 5 2/5, bottom 5 4/5). We can interpret that if the managers are assigning priorities appropriately, with longer projects they are more concerned about varied complexity than they are about workload differences between the projects.

No other apparent differences exist and most projects were similar in the number of staff per project. There is one outlier, a manager who has 12 staff members per project. That manager's top choice for prioritizing was by MTS, which is useful for projects that start simultaneously.[34]

Research Limitations

Limitations of this research include the small sample size of the survey, and the limited scope of the study, as it was conducted at one urban research center. There is also an obvious selection bias. The respondents were all at the senior level, suggesting they must have had success in project management to reach that level. In addition, some respondents provided feedback on how to improve the survey. Other key information could be collected, such as the dynamic nature of the projects—whether these projects started at similar times, making some rules more applicable, as well as staff experience and budget details. Finally, the survey could gather project failure information such as whether projects were compromised in scope or if budgets or timelines were met.

The setting of priorities must also be considered with other best practice principles for project management to have efficient use of research resources. Other examples of best project management practice are limiting tasks to 5 to 10 days, having a project with fewer than 10 members, assigning responsibility for awareness to contingencies, building appropriate slack and financial buffers, managing expectations, and encouraging informal and formal communications.[35-41] In the future, individuals who are designated as project management professionals (PMP) from the Project Management Institute may become more common.[42] This designation will establish the project manager as a professional who understands and can implement the best practice principles.

Conclusions

In this paper, we reviewed the medical, economic, business, and operations literature on the best practices for setting priorities in multiple projects. We gathered and summarized evidence on managing multiple complex and limited-resource projects. A survey was conducted of senior managers of multiple projects at a healthcare research academic institution. The survey results were compared to literature evidence to see if best practices were being followed. Based on the literature evidence and survey results, the managers who completed the survey rarely deviate from literature recommendations.

Overall, the current use of priority rules for managing multiple projects at a university is supported by evidence. When the number or length of the projects is increased, the pattern of priority rule setting is supported. Some priority rules should be dropped based on project characteristics. Problems with the managers included the use of MTS and RSM when better rules were available. RSM is best for weakly constrained projects. Even then, RSM is inferior to other priority rules such as LFT. MTS is an inferior rule and should only be used when similar projects start simultaneously.

Managers of multiple projects are required to simultaneously manage multiple resources and multiple budgets effectively to achieve project completion on time, on budget, and within specifications. One option for this difficult task is to continually update and revamp tools such as Gantt charts for each project for every delay or change in status. Alternatively and supported by this literature review, a manager can manage multiple projects by using sample simple rule-of-thumb priority rules and be even more effective. This article provides guidance in determining which priority rule is appropriate for a given project environment and project characteristics.

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Table 1

Best Practice Recommendations Based on the Literature

Priority Rule	Definition	Conditions
First Come First Served **(FCFS)**	Assign the first eligible activity the highest priority, regardless of other factors.	With simple tasks and when new projects arrive randomly (dynamic)[43, 44]
Shortest Activity for Shortest Project **(SASP)**	Assign activities that are feasible in a short period of time with preference for short projects.	Many simple tasks with few constraints, or when there are many short projects[45, 46]
		Multiple dynamic projects, low resource demand[47]
Maximum Total Work Content **(MAXTWK)**	Assign activities that require the most resources, regardless of deadlines.	Under conditions of high resource demand[48]
		Multiple dynamic projects, high resource demand[49]
Resource Scheduling Method **(RSM)**	Assign priority to activities that are time sensitive subject to resources.	Static projects with low or high resource demand[50, 51]
Most Total Successors **(MTS)**	For two similar projects, assign priority to the project with the most number of activities remaining.	Static projects that have started simultaneously[52, 53]
Minimum Late Finish Time **(LFT)**	Assign activities by due dates, with priority given to activities that if there was a delay in starting, the project duration would be extended.	Increased complexity of problems[54]
		Increased network complexity[55]
Minimum Late Start Time **(LST)**	Assign activities by earliest available starting time, so that if there was a delay in starting, the project duration would be extended.	Single project, no constraints[56]
		Many simple tasks when resources are constrained[57]
		There are different skill levels, and possibilities of errors in estimating work, and with activity misspecification (reworks)[58]
		Multiple projects, low resource constraints[59]
		Under conditions of learning[60]

Priority rules are in order of increasing complexity.

Table 2

Survey Responses

Part A: Most Commonly Used Priority Rules

	FCFS	SASP	MAXTWK	RSM	MTS	LFT	LST
Always	0	0	1	0	0	2	1
Very Often	1	3	4	5	5	4	2
Sometimes	7	5	4	3	4	1	3
Rarely	1	1	0	2	1	1	2
Never	1	1	1	0	0	2	2
Not Applicable	0	0	0	0	0	0	0

Priority Rules: First Come First Served (**FCFS**), Shortest Activity for Shortest Project (**SASP**), Maximum Total Work Content (**MAXTWK**), Resource Scheduling Method (**RSM**), Most Total Successors (**MTS**), Minimum Late Finish Time (**LFT**), Minimum Late Start Time (**LST**)

Table 3

Project Characteristics and Top Choices

	Description of Projects Currently Being Managed					Top Rules Chosen		
Respondent	Number of projects	Project duration (years)			Staff / project	First choice	Second choice	Third choice
		Min.	Typical	Max.				
1	25	0.25	2.5	5	2	LFT	MAXTWK	MTS
2	20	1 month	0.5	5	2	SASP	RSM	MTS
3	17	1 week	1	2	1.5	MAXTWK	LFT	-
4	15	0.5	1.5	4	2	LFT	LST	MAXTWK
5	7	0.5	1.5	3	2	RSM	MAXTWK	MTS
6	5	1	4	6	2	LFT	MAXTWK	RSM
7	5	0.5	2	3	12	MTS	LFT	LST
8	4	0.25	1	2	2.5	SASP	MAXTWK	RSM
9	3	1	2	4	3	LFT	SASP	FCFS
10	2.5	1	2	4	1.5	LFT	MTS	RSM
Mean	10.4	0.5	1.8	3.8	3.1			

Priority Rules: First Come First Served (**FCFS**), Shortest Activity for Shortest Project (**SASP**), Maximum Total Work Content (**MAXTWK**), Resource Scheduling Method (**RSM**), Most Total Successors (**MTS**), Minimum Late Finish Time (**LFT**), Minimum Late Start Time (**LST**)

Figure 1

Activity boxes and time-based priority rules

Figure 1A. Activity A

0	A	5
2		2
2	5	7

Figure 1B. Activity B

0	B	3
3		3
3	3	6

Figure 1C. Key

EST	ID	EFT
SLACK		SLACK
LST	Duration	LFT

Figure 1. Two activities that can be described by the following activity boxes. Both A and B can start at time zero (EST = 0, the first day of the project). Activity A has a duration of five days, and B has a duration of three days. Activity A has an LST of two days and B has an LST of three days. Thus, A has a slack of two days, while B has a slack of three days. Under a priority rule of Minimum LST, A is chosen of over B because LST = 2 for A, LST = 3 for B. Similarly, under a minimum LFT rule, B is chosen over A because LFT = 6 in Activity B is less than LFT = 7 in activity A.

Appendix I

Survey: How to Manage Multiple Projects When Resources Are Constrained

The detailed scheduling of all activities in multiple projects is a very hard computation problem to solve. Instead, project managers rely on heuristics (rules of thumb) to prioritize activities. An activity is any action that takes time.

The following is a short survey on priority rules in a Resource Constrained Multiple Project Scheduling Problem. Described below are seven priority rules for assigning activities for multiple projects.

- Please indicate if you use any of these priority rules.

1. First Come First Served (FCFS). Projects underway take precedence over new projects. A project manager would assign activities to complete the projects underway before assigning activities to begin new projects.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

2. Minimum Late Finish Time (LFT). All activities have an early finish time (EFT) and a late finish time (LFT). EFT describes the earliest an activity can be completed. LFT is the latest an activity can finish and not delay the following activity. The difference between EFT and LFT is slack for that activity. By choosing the minimum LFT, priority is given to the activity with the smallest slack in finishing times at the activity level.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

3. Minimum Late Start Time (LST). LST is the latest a project can start and not delay a subsequent activity. Similar to LFT above, each activity has an early start time (EST), which is the earliest time an activity can begin, and a late start time (LST), which is the latest day an activity can begin. The difference between EST and LST is another measure of the slack for that activity. By choosing the minimum LST, precedence is given to the activity with the smallest slack in starting times at the activity level.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

4. Maximum Total Work Content (MAXTWK): Activities are assigned priority by largest work content at the activity level, where work content is the joint measure of duration and amount of resources across all resource types.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

5. Most Total Successors (MTS): Priority is given to the activity with the most number of successor activities. Successor activities are activities that depend on completion of the current activity to begin.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

Appendix I

Survey: How to Manage Multiple Projects When Resources Are Constrained (continued)

6. Resource Scheduling Method (RSM). RSM gives precedence to activities that will delay the project the most. In particular, it gives precedence to activities that have subsequent activities that have been waiting to start the longest.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

7. Shortest Activity for the Shortest Project (SASP). SASP gives precedence to activities that can be completed quickly to complete short projects.

Always	Very Often	Sometimes	Rarely	Never	Not applicable

Part B: Please rank the top three as being the most appropriate to your project scheduling success.

First choice: _____
Second choice: _____
Third choice: _____

Part C: Please answer the following questions.

What is the current number of projects you manage?	
What is the typical project length?	
What is the minimum project length?	
What is the maximum project length?	
What is the typical number of staff per project?	