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The Impact of Task-Methodology Fit on CPM/PERT Diagramming Performance: An Experimental Investigation

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ABSTRACT

We propose to investigate students' performance as they construct CPM/PERT network diagrams. Our investigation will have two parts. The first is comparison of performance of students using one of two methodologies for constructing the diagrams – we want to understand which methodology is more efficient and effective. The second aspect will entail investigation of the impact of the interaction between methodology and task features in the construction of these diagrams. Our two measures of performance, efficiency and effectiveness, will be captured by measuring the time spent constructing diagram and the accuracy of diagram construction as denoted by a grade assigned to the outcome. Our tasks will vary according to the information presented to students for constructing the diagrams. We will conduct a 2x2 factorial experiment with students and analyze our experimental data using a 2-way MANOVA. Our expected contributions include recommendation of alternative methodologies for teaching students how to construct network diagrams as well as specific task features for each methodology. We also hope to gain insights on students' relative preference for the methodologies.

Keywords: CPM/PERT Construction, Performance, Efficiency, Effectiveness, Experiment, MANOVA, Project Management.

INTRODUCTION

The Critical Path Method/ Project Evaluation and Review Technique (CPM/PERT) is used to develop network diagrams to aid in scheduling and managing complex projects. Therefore, the ability to efficiently and effectively construct these diagrams is very important for project managers. CPM/PERT also serves as the primary technique used in universities and colleges in Project Management and related courses (Galloway 2006). The technique helps students to appreciate elements of project scheduling including evaluating project duration, critical path analysis, and project crashing.

In industry, diagramming is usually performed with the aid of sophisticated software systems. However, in the classroom, these diagrams are developed manually. The expectation is that, by manually executing these diagrams, students will, in the process, understand critical elements of project scheduling and management. In these classroom settings, students are not only learning, but are also being evaluated; therefore, the methodology used to teach project diagramming is important because it then becomes the methodology which they in turn use. Diagramming methodology seems therefore to be an important factor of task performance – the efficiency and effectiveness with which students are able to execute on assigned diagramming tasks.

The classical approach to teaching and manually constructing CPM/PERT network diagrams, is to construct the network from left to right -- that is to say, from starting activities to finishing activities (Anderson et al. 2015; Taylor et al. 1996; Valle and Lanier Jr 2016). However, in a recent classroom experience, we discovered that a few students appear to understand the construction and performed better when constructing the diagram from right to left – that is to say, from finishing activities to starting activities. We therefore seek to compare these two methodologies.

We argue that the information given to students for constructing project networks as well as the methodologies they are taught to use will impact their performance in constructing these diagrams. We also argue that students, given a choice, may elect to use one methodology over another if the same information is given for the task. We therefore expect that having different approaches for teaching students how to construct network diagrams will be beneficial to the teaching process. The purpose of this paper is to present our proposal for analyzing the relative performance of students using two methodologies for constructing a CPM/PERT network diagram when two sets of project activity data are supplied.

We will conduct an experiment with students to compare the performance outcomes of the two methodologies, and to investigate the impact of task-methodology fit on performance in the construction of these diagrams. Experiments are known to be very effective in establishing causal relationships, and, although low on generalizability, they have been shown to be high on precision in control and measurement of variables related to behavior(s) of interest (McGrath 1981). We measure students' outcomes using two performance variables and so we will also conduct a multivariate analysis of variance (MANOVA) to determine the results of our experiment.

The rest of the paper proceeds as follows. In the next section, we provide our research model which also shows our hypotheses. We follow with details of our proposed research methods. We then show samples of the tables that we will use to present our results and end with some anticipated contributions of our research.

RESEARCH MODEL AND HYPOTHESES

Task-methodology fit has been hypothesized as one factor that will impact task performance (Antony and Mellarkod 2004). We propose that performance in constructing network diagramming will be highest when students: (1) having knowledge of

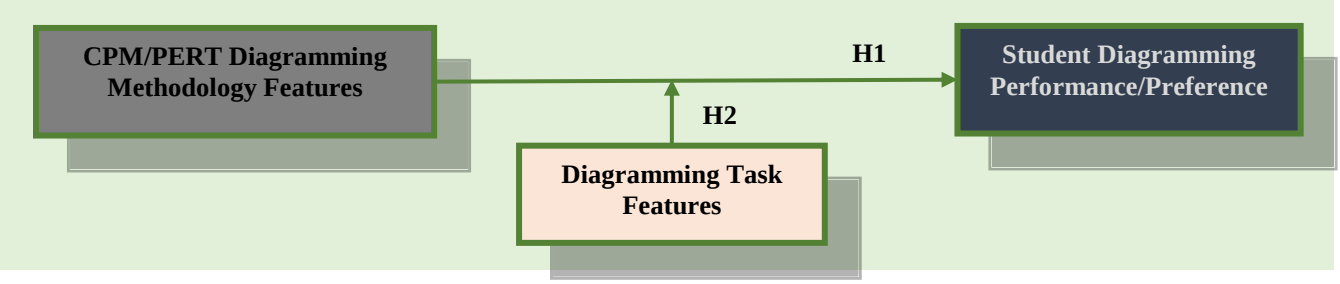

Figure 1: Model of METHODOLOGY-TASK Fit for Student Diagramming Performance

the immediate successors, construct network diagrams from starting activities to finishing activities -- left to right; and (2) having knowledge of the immediate predecessors, construct the diagram from– right to left. We also argue that students' preference for a particular methodology will depend on the knowledge provided with the task. Our research model is shown in Figure 1.

- For comparison of the two methodologies on our dependent variables (H1), we hypothesize the following:

  H1A$_o$: The population mean of the outcomes using a particular methodology for performing a given task will be equal to the population mean of the outcomes using a second methodology for performing the same task.

  H1A$_a$: Population means for the task using the two methodologies are not equal.

- For the interaction effect – the Task-Methodology fit - on Performance (H2), we hypothesize the following:

  H2A$_o$: The population mean of the outcomes related to constructing a project network diagram will vary based on the features of the task and the methodology used to develop the diagram.

  H1A$_a$: Population means for the task will remain constant regardless of the task features and the methodology used.

RESEARCH METHODOLOGY

We will conduct a controlled laboratory experiment with undergraduate students as subjects to investigate our hypotheses. We provide more methodology details next.

Research Task

We will use two research tasks for our experiment. The correct outcomes will be the same network diagram; however, the tasks and the methodologies will vary. For each research task, emphasis will be placed on including characteristics such as: two or more starting activities; two or more ending activities; at least one activity with two or more predecessors; and, at least one activity with two or more successors. The tasks will vary only in whether data provided for the diagram construction includes activity predecessors or activity successors.

Data Collection and Variable Operationalization

In addition to the data collected in the experiment, we will conduct a pre-test survey of all participants to collect data related to their GPA's, age, gender, and project management experience outside the classroom. We will also conduct a post-test survey of all participants to collect data related to their methodology preference. Since each subject will use both methodologies, we will be able to assess preference for a given methodology.

Our independent variable will be the methodology used to perform the task. Methodologies will vary according to the direction of construction of the network diagram -- left-to-right construction or right-to-left construction. Our moderating variable will be task features which will vary according to whether predecessor successor data are given for the project

activities. Our independent variable, students' ***performance***, will be measured using two variables: *efficiency* will be measured by the time taken to complete the diagram; and *effectiveness* will be measured using the accuracy of the diagram construction. A standard rubric will be used to grade all the diagrams constructed in the experimented.

Experimental Design

We will employ a 2x2 factorial design. Subjects will be randomly assigned to one of two sets. Each set will provide data that will for comparison of the main effect -- diagramming methodology. Members of each set will therefore receive the same research task and will construct the network diagram using both methodologies. Set 1 will receive the research task that provides predecessor data for project activities and asked to construct the diagram using the two methodologies. Set 2 will receive the research task that provides successor data for project activities and asked to construct the diagram using the same two methodologies. Therefore, overall, the experiment will be conducted in four sessions. Table 1 depicts the design. For each session, tasks will be timed on completion – for efficiency measurements, and graded after completion – for measures of effectiveness.

	Methodology *(IV)*	
Task Features *(IV)*	*(Type)* Left-to-Right (L-R) Construction	*(Type)* Right-to-Left (R-L) Construction
(Data) Predecessors -- Set1	L-R construction with Predecessors	R-L construction with Predecessors
(Data) Successors -- Set2	L-R construction with Successors	R-L construction with Successors

Table 1: 2x2 Factorial Design

Participants

Third and fourth year undergraduate student at a large university will be recruited to participate in the experiment. All subjects will have successfully completed a course in Business Analytics, in which they will have learned hands-on skills in the construction of project network diagrams using the two methodologies and with the two types of tasks.

Analysis

We will conduct a 2-way MANOVA on our two performance variables: efficiency; and effectiveness.

RESULTS

Our results will include the analysis of the experimental data which will be analyzed and presented as depicted by Table 1.

	Student Efficiency			**Student Effectiveness**		
Variables	**Mean Square**	**F-Statistic**	**p-Value**	**Mean Square**	**F-Statistic**	**p-Value**
Covariates						
• Project Experience						
• GPA						
• Age						
• Gender						
Main Effects						
• Methodologies						
Moderating Effects						
• Task Features						

Table 2: Presentation of Analysis of Data Collected for Task-Methodology Fit in Experiment

ANTICIPATED CONTRIBUTIONS

The primary purpose of this study is to evaluate the relative performance of a new methodology both for teaching students how to develop CPM/PERT network diagrams and for their own use in constructing the diagrams. The evaluation will entail a comparison of the new approach with the classical approach on the basis of four criteria: effectiveness; efficiency; and user preference. If the new approach is more efficient and/or effective and is preferred, then an alternative methodology for teaching CPM/PERT becomes available to educational institutions and text-book writers. Because mastery of CPM/PERT diagramming is desirable for business students, it will be especially important if a methodology that enhances the learning experience is uncovered. However, successful or not, there is the potential to identify some of the relative advantages and disadvantages of each method in order to seek to improve our ability to transfer knowledge to students on this subject matter.

Using the data from the pre-test, the experiment is expected to enhance our understanding of how students with varied levels of preparation comprehend network diagramming approaches. Using the results of the experiment, we hope to gain some appreciation of where problems occur with students and their cognitive processing as concerns the impact of the task features – the data they are asked to use in modeling project network diagrams. Such understanding can be used in the future in classrooms, textbooks and studies that seek to improve CPM/PERT network modeling.

This research is in progress. All experimental materials have been developed. It is anticipated that by the time of the conference, the materials will be pretested, some data will have been collected and some results will be available for presentation.

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