

A QUALITATIVE APPROACH IN PROBLEM SOLVING PROCESS TRACING OF CONSTRUCTION SITE ENGINEERS

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The construction project success greatly depends upon the effectiveness of problem solving process exercised by site managers. This process has been explored to investigate factors impeding its effectiveness. Ninety-nine civil engineers were presented with common on-site problems through various informal intuitive and formal non-intuitive tools and techniques. The nature of tools employed is found to have an effect on problem recognition. Factors like management and technical cognitive styles, the phenomenon of 'selective perception,' non-existence of mental models of problem and cognitive biases are found associated with informal tools usages. The study reveals a lack of meta-cognitive awareness among some engineers regarding the problem solving process and their role as a site manager. Non-intuitive formal tools help frame the problems in a more rational and logical way not affected by these psychological factors. The use of non-intuitive tools employed was not found to be difficult and their non-use may be attributed to the unawareness of the existence of such tools. Variations in the problem solving processes exercised by the engineers question the present definition of experience and its value as a measurement of expertise. The focus group interview approach assisted to develop some insights into the current practice of site managers.

Keyword: construction experience, decision making, site management, site engineer

INTRODUCTION

From all stages of construction project starting from design to completion, the construction stage is the largest and the most important in terms of time required to completion and the amount of money to be spent for actual construction. This stage is responsible for the conversion of the ideas into physical shapes. To accurately predict or assess all problems concerned during this stage is a truly difficult job because of the unpredictability of the on-site construction environment. Unexpected problems are inevitable on construction projects because predictive and preventive techniques can never be perfect (Loosemore, 1994).

The construction process involves the particular movement of tools, material and workers. The arrangement of the work place characteristics, the scheduled time, and inspection criteria all make the environment complex and uncertain due to which predictability becomes truly difficult (Bennett, 1983). If most on-site problems go unnoticed at the early stage, they may create a lot more trouble later leading to decreased site productivity and finally schedule delays and cost overruns.

Monitoring and control are attempts to spot problems while the project is in the execution stage. The key to problem recognition lies in comparing actual progress to

planned and locating the causes of variance if difference exists. Problems come from every dimension once construction is started. These may be technical or managerial. Often technical problems are more obvious and there are well-defined procedures to deal with them. Managerial problems are tackled by the site organization that is established solely for accomplishing site tasks as planned to ensure project completion. Mustapha and Naoum (1998) were of the opinion that the site manager stands at the heart of the building process and his or her ability will strongly influence the success or the failure of the project for the contractor, the professional team, the client and ultimately the general public. This is the most significant and important person whose skills will take the project to completion and whose abilities decide the fortune of the venture.

Site managers are expected to act as trouble shooters by recognizing and pinpointing problems (Belassi and Tukel, 1996) before they expand to uncontrollable proportions. It is their duty to perceive the problem first, see if can they solve it and, if not, pass it to a higher level as soon as possible (Mastrandrea, 1986). The key lies in the recognition of the problem, the solution comes later. Site managers usually adopt different means and modes of recognizing a problem. Oglesby *et al.* (1989) categorized such techniques as informal and formal assessment methods. Informal assessment methods are visual observations or face-to-face simple talk with workers and recognizing a problem by intuition. This method may be misleading as it depends upon human judgement. At the same time, it is quick, often correct and saves cognitive effort of managers (Skitmore *et al.*, 1989). It is a psychological trait of humans that they want to obtain and process as little information as possible because of limited information processing capabilities (Santamarina and Chameau, 1989). It is also believed that 80% of the human brain is concerned with visual imaging and that vision provides the greatest input to the brain (Brandon *et al.*, 1998). There is, therefore, a tendency in human beings to rely on judging things visually.

PROBLEM STATEMENT

Site managers are responsible for the smooth running of site operations. Complex construction processes are associated with both foreseen and unforeseen problems. Site managers employ problem solving processes to trouble shoot such problems. In this regard they make the use of various intuitive and non-intuitive tools and techniques. Unforeseen problems cannot be anticipated but if the foreseen problems become unforeseen merely because the site managers failed to recognize them or are not able to employ effective problem solving processes, the setback is great. Several studies (Kaming *et al.*, 1998; Olomolaiye, 1987) have associated the cost overruns or schedule delays to various on-site problems. This shows that these factors are either not being effectively recognized or controlled by site managers. This leads to the notion that problem solving processes employed by the site managers may not be effective. Hence, there is need to explore these processes to see various, attributes or factors that may render this process ineffective. It is also to be confirmed whether the nature of the management tools or techniques employed to assist the problem solving process produces an effect on this process or not. For the commonly adopted management tools and techniques, it is interesting to find out their ability and deficiencies to give insight in problem identification and recognition, and to also find out the awareness and knowledge of site managers to use these techniques successfully. The research study sets out to explore these questions.

Objectives

The main objective of the study is to explore the problem solving processes exercised by site managers through the use of various tools and techniques employed to aid this process. As sub-objectives, the study examines the effect of the nature of the tool employed and influence of engineering experience on the problem solving processes. This study also explores the rules of thumb that site managers use for handling site matters and provides some insights into their current practice.

The study focuses only on the on-site process and does not deal with off-site factors. The term “site manager” has been adopted to cover all range of personnel present on site responsible for direct supervision, irrespective of the parties involved (contractor or consultant). The tools and techniques used in the study are directly related with on-site productivity. The tools that indirectly aid on-site problem solving, as cost and schedule related analysis, have not been employed in this study.

THEORETICAL BACKGROUNDS

A site manager has various tools and techniques available for on-site monitoring to obtain information. He or she must be able to comprehend the information generated by these tools properly to spot the problem. This has a great impact on project performance as correct interpretation of the information will lead to recognition of a problem that can be dealt with before it becomes critical. Various researchers (Mustapha and Naoum, 1998; Belassi and Tukel, 1996) have studied the impact of site manager performance on project success or failure, but they indirectly measured site managers’ abilities e.g. asking their immediate bosses about their performance or checking various projects on which they had worked to see if they were successful. Little research has actually intervened in site practices to explore management styles in real situations. Such research is necessary to improve site managers’ abilities through education and training.

Use of tools and techniques

Formal assessment methods are used to check ‘slippage’ in schedule and cost overruns. Slippage alerts managers that something is wrong with work face operations. If an important operation takes considerably longer than the time given for it in the schedule or if the reported unit costs overrun the budgeted amounts substantially, something is wrong. This is a good method for assessing or pinpointing problems, but there is a danger in relying exclusively on schedules and cost reports if they are based on inaccurate information, which is not proactive. One of main reasons for the non-use of information systems is that they cannot provide up to date information in a timely manner or format that is understandable to site personnel or compatible with their cognitive styles or limitations (Wilson, 1995). Davenport (1994) also found that managers do not use the information that comes out of machines but prefer to obtain information that comes verbally thorough mutual co-ordination and co-operation.

Ahmed and Minkarah (1990) found that construction personnel prefer techniques that use less mathematics and will adopt these more easily rather than other techniques. Information systems that cannot process data to the extent that management information coming out does not involve further mathematical manipulation will not be successful as far as site personnel are concerned. Expert systems can be helpful to find the solutions of the problems encountered but cannot recognize the problems.

The use of technical or mathematical methods depends on education, experience and general thinking skills of site managers. General thinking skills refer to cognitive abilities, specifically visual thinking and verbal and logical reasoning which are used in recognizing, analysing and solving problems (Loy, 1991). Site managers have different abilities and gauge similar situations differently and in accordance with practices they find comfortable and have had success with in the past. They have developed various 'rules of thumb' or 'heuristic' practices. These cognitive short cuts are part of the professional skills they have developed over time through experience and are in part, a function of age, training, qualifications and management style (Mustapha and Naoum, 1998). The problem is that these criteria may not be consistent and vary from person to person.

Formal and informal methods

Formal methods directly give information about how well a certain construction process is being carried out. Site managers interpret the data for meaning and then take an appropriate action to resolve the problem. Mostly, these tools are related to the optimum utilization of resources (i.e. material, equipment and labour). These methods give a fairly good idea of utilization of resources that directly contribute to work and anything wrong can be pointed out efficiently. The most common methods are, for example, foreman delay survey, work sampling, video recorder, computer simulations, process flow charts, crew balance charts, and so on.

The informal methods employed on the site are normally associated with routine daily work assignment and activities. Visual observations are simple and frequently used by site managers because its use is natural. Site managers visually observe the site works and gauge its progress. The tool provides a large amount of visual information, which is processed by site managers and translated into meaningful knowledge that may result in recognizing a problem. Hence, the tool greatly benefits site managers by helping them to recognize the indicators or various events happening on site as symptoms of potential problems and thus making timely trouble shooting possible. Use of this tool has an advantage of keeping pace with construction process but it does have various disadvantages because of its intuition dependent limitation. All construction managers from top to bottom in the field organization will say that they can judge how well a work-face task is being carried out merely by watching it for a short time. What they often fail to recognize is that their judgements have some cognitive limitations associated with various biases that may distort their judgement (Santamarina and Chameau, 1989).

Heuristics and biases in judgement

'Heuristic' is a term used by psychologists to denote general problem solving procedures that often work in solving everyday problems. It is a rule-of-thumb, a guideline for coming up with a solution (Best, 1986). The use of heuristics is very much used in construction projects. Skitmore *et al.* (1989) mentioned that cognitive heuristics or principles are systematic rules which operate instead of a detailed analysis of the available information thus conserving mental effort.

Most site engineers' decisions are made under uncertainty. Most people do not evaluate uncertainty, subjectively, they act to reduce or avoid uncertainty, which they consider the property of the environment rather than something within themselves (Santamarina and Chameau, 1989). Actually uncertainty relates to one's limited comprehension of a phenomenon and its complexity. Under uncertainty, a person tries to make a decision that may prove wrong.

METHODOLOGY

To explore the problem solving characteristics of site managers various common problems were presented in pictorial forms that involve visual observation and judgement skills of the respondents to recognize the problem, its cause and appropriate solution. For exploring the use and knowledge of various tools and techniques that are associated with formal direct problem assessment methods have also to be presented and the problems are depicted through these tools and techniques. Site managers need to comprehend these techniques to understand the problem presented, the proper cause and appropriate action. The design of methodological framework is shown in Figure 1.

In this study, the web-based questionnaire, referred to as “the virtual site,” was developed to graphically illustrated site information captured by various techniques. The virtual site consisted of various components. These components are the tools and techniques in themselves that site managers use to aid their problem solving process. These can be classified as informal and formal/direct tools. The virtual site consisted of 5 components: Informal tools like visual observation (photographs of common site problems); a formal direct tools like work sampling; crew balance chart; process flow chart and a video recording. The virtual site looks at the use of these tools and techniques and provides some insights into their application for problem solving.

Respondents

A total of 110 civil engineers responded to the web-based questionnaire. Ninety-seven responses were found complete and analysed. The respondents were categorized by the level of experience from 0 to more than 15 years and in age from 23-47 years. They come from construction and related fields of civil engineering.

All respondents (97) were graduate students in the School of Civil Engineering at the Asian Institute of Technology. Thirty-seven have direct experience in construction. Direct experience means they have worked on a construction site as a site supervisor or in a capacity in which they made frequent visits to a site. About twenty-one were inexperienced and forty have experience but in fields other than construction fields. Respondents were mainly graduate students studying in various departments of civil engineering at AIT, mainly construction management, structural, transportation and irrigation engineering.

Qualitative technique for data analysis

The most common technique used for qualitative data analysis is known as “Textual Analysis”. It is a method communication researchers frequently use to describe and interpret the characteristics of recorded or visual message. These texts can be written transcripts of speeches and conversations, print or electronic documents, paintings, photographs etc. (Frey *et al.*, 1991).

Content analysis was chosen as the most appropriate approach for analysing the type of data gathered in this research. The open ended questions in this interview have been answered in a variety of ways by various participants and hence require interpretation of their intentions and opinions and provide an insight in their thinking processes.

In this research, where the question is to describe any kind of problem, causation or action, as felt by a respondent, certain inferences can be made by objectively identifying specified characteristics (problem, causation, actions) in the text.

Focus groups

This qualitative approach has been used for the accomplishment of the “Exploration of rules of thumb.” Focus groups served the following purposes:

Knowledge Elicitation: Focus groups made it possible to elicit the knowledge relating to the practice of site managers and helped in gaining insights and developing understanding of various related processes or phenomenon qualitatively exploring their strengths and weaknesses.

**Simple/Qualitative/
Intuitive**

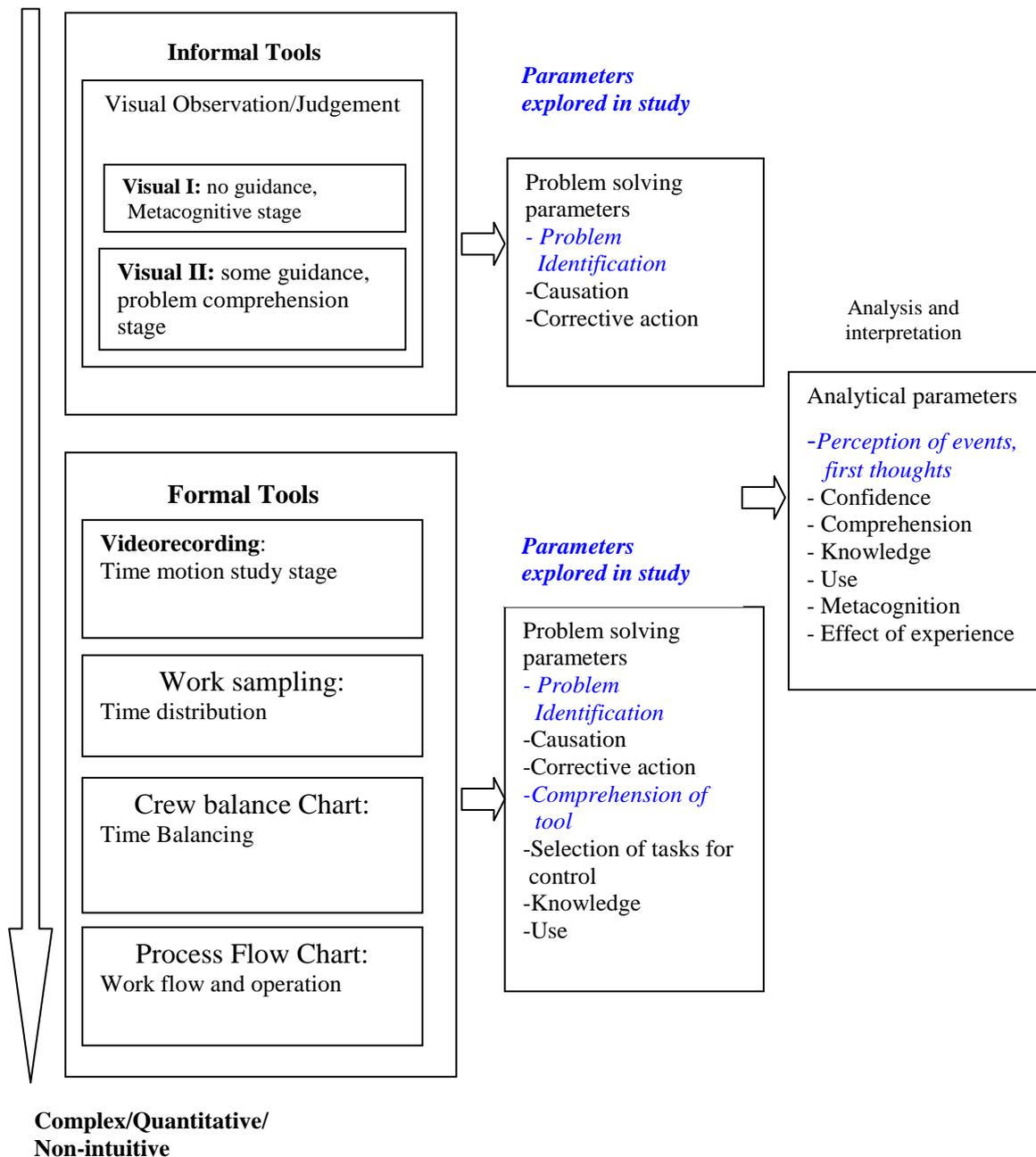


Figure 1: Framework to evaluate the use of tools in assisting problem solving process

Validation and Verification: Focus groups also helped in validating and verifying the analytical framework used for analysing the first part of the research and obtaining the related comments and suggestions useful in improving the framework and interpretation of results.

After information from the web-based questionnaires were preliminary analysed, three sessions of focus groups were held each for about two and half hours. A total of 11 participants with the experience in construction works for more than 8 years participated in this interview in all the three sessions.

RESULTS

Informal intuitive tools

Informal tools elicit a variety of answers because of their qualitative and intuitive nature. They make it possible to observe the phenomenon as ‘selective perception’, ‘Influence of cognitive biases’, ‘metacognition and unawareness’, comprehension of problem, identification of proper causation and confidence in suggesting action.

For visual observation and judgment, it can be interpreted that most respondents in their first thinking were not conscious of what to look for in the site operations presented pictorially when they are not guided. A few who were able to identify the problem didn’t think further of interpreting the cause and suggesting some corrective action. Such response from the direct experience group showed that they are not clear of their role as site manager and this demands the shifting of perception and making them aware of their role as a troubleshooter.

The response to the problem identification increases by providing the guided questions in next stage. The in-experienced person who could respond well can be thought of doing so based on their intelligence and making use of the first-degree education. In this stage, it has been found that most respondents are biased towards the safety and they have defined this problem indiscriminately even in all those events where it is not a primary problem. Similarly, it is true for the cause as “poor supervision”. Both are true for the construction processes and respondents can easily recall these two in relation to the construction process under the influence of ‘availability bias’. Some of the participants showed their inclination towards technical problems, which may be referred to the influence of technical education in case of inexperienced group or the participants are working as consultant if they belong to the group with direct construction experiences. The consultant has a tendency to look more for technical problems. Some of the respondents could identify the problem but could not interpret proper cause and suggest some appropriate action. This may be indirectly interpreted as either the person are not aware of what to do or they lack confidence.

Formal non-intuitive tools

These tools elicit somewhat uniform response with not much variation. The benefit of these tools are found in the problem identification stage of problem solving process as they quantitatively express the process and respondents do not need to exercise their judgement.

Most respondents expressed their unawareness about these tools, even if they are from direct construction experience group. However, the use of tools is not found to be difficult as most can still comprehend them and identify the appropriate problem. This

demands that these tools should be publicized and introduced as one of the main objectives of the training course.

Work sampling chart and detailed work sampling sheet was comprehended thoroughly by various engineers who have not heard of this before so the tool itself does not found to be difficult and needs to be publicized. Process Flow Chart was comprehended by more respondents as compared to the Crew Balance Chart, may be because of large scale of operation that it shows or maybe less cognitive load that it offers as stimulus.

Video recording is found to be a good mixture of both formal and informal method and can be used in any way one likes. Intuition and judgement (Informal) can be employed later on the recorded clips and if possible time motion studies (Formal) may be made. Some respondents were able to comprehend the problems depicted in the video film. Most persons repeated the clip 2-3 times before making any judgement about the problem. The basic advantage of this tool to play the things time and again were not mentioned by most respondents, however, they do provide its benefit in one form or other as help in claims, noting performance of workers etc.

CONCLUSIONS

The main objective of the study is to explore the problem solving processes of the site managers thorough the use of various tools and techniques and examine the influence of various natures and level of civil engineering experiences. The research exhibits both management and technical thinking styles of civil engineers. Among management problems there are extreme variations among perceptions of actual problems. This indicates clearly that engineers have different mental models even for the same site events. The variation in mental models gives rise to the phenomenon of 'selective perception.' The research concludes that as the use of informal tool are inevitable because of their simplicity and naturalism, above mentioned factors impeding the process of problem solving process while use of these informal tools need to be addressed to minimize their effect in effective problem solving.

Formal tools as they rationalize the problem quantitatively and non-intuitively so there is not much variations identification process. The responses for these tools elicit either management problem, that comes if the information presented is comprehended, or no problem if it cannot be comprehended. These tools are no longer affected by 'selective perception' or 'cognitive bias'. It has also been noticed that the formal tools explored in this research are not difficult because they were able to elicit the appropriate response from the persons who have never used them or even know them.

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