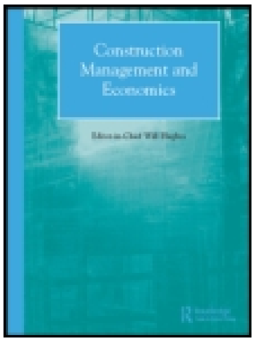

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Conceptual delay mitigation model using a project learning approach in practice

Hamzah Abdul-Rahman , Imran Ariff Yahya , Mohammed Ali Berawi & Low Wai Wah

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Conceptual delay mitigation model using a project learning approach in practice

HAMZAH ABDUL-RAHMAN, IMRAN ARIFF YAHYA, MOHAMMED ALI BERAWI and LOW WAI WAH*

Faculty of Built Environment (Fakulti Alam Bina), University of Malaya 50603, Kuala Lumpur, Malaysia

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There is universal agreement that construction delay is a common phenomenon in the construction industry worldwide. Poor or lack of project knowledge management continues to plague the construction industry, especially in relation to project delays. Knowledge management is used to reduce the impact of construction projects delay using a project learning approach. Three different phases of data collection were used for the development of a delay mitigation model, namely preliminary survey, case studies and interviews survey. The project learning approach contributes towards positive impacts on project schedule performance. Also, good leadership and integrated commitment of all project parties are the principal impetus to improve the delay phenomenon in the construction industry. The conceptual model incorporates knowledge on knowledge management, project learning, lessons learned feedback and supervisory control principles. The results indicate that the application of project learning is a way to align the project schedule performance to client and market needs while maintaining the contractor's core competency.

Keywords: Delay, knowledge management, project learning.

Introduction

There is universal agreement that delay is a common phenomenon in the construction industry worldwide (Chan and Kumaraswamy, 1997; Frimpong *et al.*, 2003; Koushki *et al.*, 2005; Arditi and Pattanakitchamroon, 2006). Timely completion of a construction project is frequently conceived as a major criterion of project success (Rwelamila and Hall, 1995) especially in the case of developing countries. In construction, delay refers to the slowing down of work without stopping construction entirely and that can lead to time overrun either beyond the contract date or beyond the date that the parties have agreed upon for the delivery of the project (Lo *et al.*, 2006).

Delay is not merely a leakage in the construction industry (Aibinu and Odeyinka, 2006), it is a catastrophe to the construction industry and to the nation. At the macro level, delay will lead to a negative rate of national economic growth (Arditi *et al.*, 1985; Lo *et al.*, 2006), monetary loss (Mezher and Tawil, 1998) and retard the development of the industry (Odeh and Battaineh, 2002). At the micro level, a delayed project can lead to time and cost overruns, dispute, arbitration, litigation, total abandonment (Sambasivan and Yau, 2007); lost of productivity, acceleration, contract termination (Arditi and Pattanakitchamroon, 2006); reduction in quality (Hong and Proverbs, 2003), and decrease in developers' financial and sales commitments (Benson, 2006).

The construction industry plays a major role in the development of many countries. In some economies, many construction projects suffer from delay (Hussein, 2003; Abdul-Rahman *et al.*, 2006a, 2006b). Lack of experience (Abdul-Rahman *et al.*, 2006a) and inadequate contractor's experience (Sambasivan and Yau, 2007) constitute the major delay factors in Malaysian construction projects. Inadequate experience contributes to poor quality of decisions, repeatable mistakes, increased time and resources to search and access the relevant knowledge and the issue of losing tacit project execution knowledge especially among senior staff in construction organizations (Lopez *et al.*, 2004). The uniqueness and constraints of each construction project

*Author for correspondence. E-mail: amethystlww@yahoo.com

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pose the biggest challenges on how to utilize appropriate existing knowledge in making decisions for current and future projects so that they can complete within the specified time, cost and quality.

Knowledge management plays an important role in the management of tacit knowledge (Robinson *et al.*, 2001; Berawi, 2004) and value achievement (Lee *et al.*, 2005; Berawi and Woodhead, 2005). In the construction industry, tacit knowledge significantly contributes to the improvement of task performance, for instance the schedule performance. Appropriate knowledge management could improve project methodologies and save design time (see the study by Hari *et al.*, 2005, which links knowledge management with the possibilities of time reduction). Reduction of time in performance improvement can be achieved through the use of knowledge management (Tserng and Lin, 2004) during the project period especially in critical delay events of the construction phase (Chan and Kumaraswamy, 1997; Abdul-Rahman *et al.*, 2006a). Moreover, knowledge and information flow between the organization levels are outlined as important considerations in mitigating construction delay (Abdul-Rahman *et al.*, 2006a).

Learning cannot be separated from and is no less important than knowledge management (Lopez *et al.*, 2004; Keegan and Turner, 2001). Both learning and knowledge management have always been the connected elements in which knowledge management encourages a structured and organized learning environment and vice versa. Learning in construction projects is thus important in governing the outcome of a project especially in the reduction of project duration (Arditi *et al.*, 2001).

Knowledge management and learning process

Drawing on the implementation impact of knowledge and learning on the project schedule performance, the conceptual model of this study focuses on four concepts, namely: knowledge management, project learning, lesson learned feedback loop and supervisory control. There exist comprehensive theories of the knowledge management process (Scarbrough *et al.*, 1999; Egbu, 1999; Tserng and Lin, 2004; Berawi, 2004; Lee *et al.*, 2005). The processes of knowledge management include knowledge identification, creation, acquisition, transfer, sharing and exploitation (Berawi, 2004; Lee *et al.*, 2005). Fong (2003) argues that collective project learning is central to the knowledge processes of knowledge sharing, knowledge generation and knowledge integration. In other words, project learning is an important process in knowledge management, especially in the project-based nature of construction projects. Project learning is a set of actions used by project teams to create and share knowledge within and across projects in two different approaches, namely: intra-project learning and inter-project learning (Kotnour, 2000). Both approaches of project learning offer a comprehensive view of learning from projects in which the former stresses the capture and use of real time knowledge and the latter focuses on the reuse of learned experience and knowledge across projects.

Feedback is fundamental in a decision process as one considers viable alternatives, compares them with expectations, and adjusts efforts in the repetition of the pre-decision, partial decision and post-decision stages (Zeleny, 1982). To ensure an effective process in learning and knowledge management, feedback can lead to the exploration and hunting of invisible or new knowledge and the assessment of lessons learned within the project (Berawi, 2006). This will subsequently help to reduce delay time in searching solutions, knowledge and rework.

Supervisory control includes efforts by management to increase the likelihood that individuals will act in ways that will result in the achievement of organizational objectives (Stajkovic and Luthans, 2001). For a construction project, which is fragmented in nature, supervisory control is important to maintain a continuous project learning process. As project learning is highly human oriented, supervisory control can produce a positive impact during the project period.

Drawing on the previous studies, the relation between the processes of knowledge management and learning management in delay management are depicted in Figure 1.

Previous studies

Factors and effects of construction project delay have captured considerable attention from researchers from various construction industries especially in the developing countries as shown in Table 1. The findings of these studies are that in practice, project delay factors depend on the types of procurement methods, geographical area and types of projects. Rather than focusing on the investigation of delay factors, it is worthwhile to consider the major delay factor(s) and to study the mitigation methods.

Another prevailing research area is on the method of delay analysis. For example, Bordoli and Baldwin (1998) proposed a systematic methodology for assessing construction project delay that focuses on the project progress and detailed out six types of delay to the construction works: date delay, total delay, extended delay, additional delay, sequence delay and progress delay. Another approach, known as delay analysis method using delay section (DAMUDS) deals with inadequate accounting of concurrent delay and

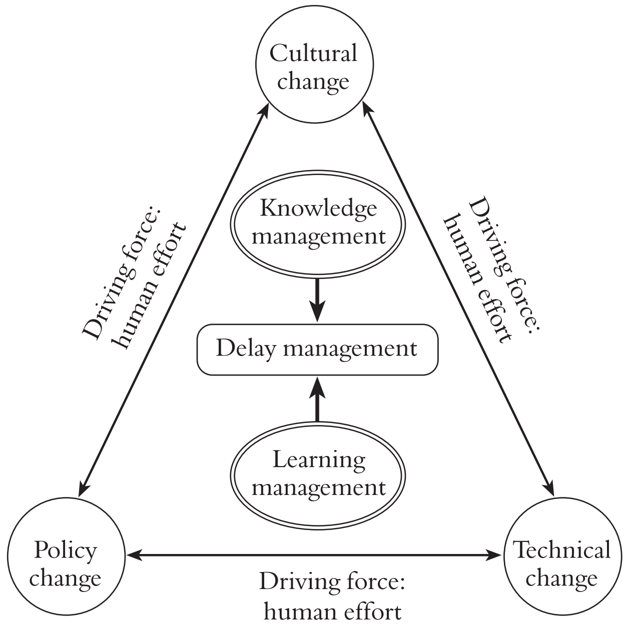


Figure 1 Principles of delay mitigation model

time-shortened activities (Kim *et al.*, 2005). Other approaches include daily windows delay analysis that considers the day-by-day fluctuation in critical path along the project duration to arrive at accurate and repeatable results for apportioning project delays among parties (Hegazy and Zhang, 2005), non-delay scheduling algorithm based on branch and bound (BB) principle (Zwikael *et al.*, 2006) and other construction delay analysis methods. However, these literatures fail to incorporate the elements of knowledge and learning in delay management.

Table 1 Summary of previous studies on causes and effects of delay in construction industry

Countries	Previous literature
Turkey	Arditi *et al.* (1985)
Florida	Ahmed *et al.* (2002)
Nigeria	Dlakwa and Culpin (1990); Mansfield *et al.* (1994); Aibinu and Odeyinka (2006)
Saudi Arabia	Assaf *et al.* (1995); Al-Khalil and Al-Ghafly (1999); Assaf and Al-Hejji (2006)
Thailand	Ogunlana *et al.* (1996)
Hong Kong	Chan and Kumaraswamy (1997); Kumaraswamy and Chan (1998); Lo *et al.* (2006)
Lebanon	Mezher and Tawil (1998)
Jordan	Al-Momani (2000)
Ghana	Frimpong *et al.* (2003)
Kuwait	Koushki *et al.* (2005)
Malaysia	Anuar-Othman *et al.* (2006); Sambasivan and Yau (2007); Alaghbari *et al.* (2007)
Indonesia	Kaming *et al.* (1997)

Apparently, there is a gap between the identified current issues and existing studies. In addition, there is scarcity of studies that focus on another perspective of delay management, that is, factors that can mitigate delay. Thus, mitigation of delay in relation to knowledge management is a subject worth investigating in the construction industry.

Analytical framework, research aim and objective

Figure 2 portrays the analytical framework of the study. The analytical framework of the research begins with a general exploration of knowledge deficiencies between existing researches and the current issue focused on in this study. The main research aim is to employ project learning as a method to reduce project delay. The research continues to obtain knowledge and practical views about the use of project learning to mitigate project delay through theories from existing literatures, surveys, interviews and real life case studies. A conceptual delay mitigation model is then developed from the analysis of a preliminary survey, case studies and the validated results of field surveys. The details of each data collection process are provided in the research methods section.

Research methods

Given the little research that exists on the subject of mitigation of delay using the project learning approach, exploratory research serves as an appropriate approach to gain information within the phenomenon of the research area. Figure 2 illustrates the data collection sequencing of three different stages for the design plan, namely the preliminary survey, case studies and surveys.

Stage 1: preliminary survey

Interviews survey

In this study, the sample of the preliminary survey composed of the contractors registered with the Construction Industry Development Board (CIDB) in Grade 7. The sampling frame is based on the Malaysian Construction Industry Development Board (CIDB) database of contractors as it is the Malaysian government agency responsible for promoting development, improvement and expansion of the construction industry and it is the accreditation and registration agency for local contractors. The registered construction companies in Malaysia are categorized into seven different grades as displayed in Table 2. The population of Grade 7 is considered as a suitable representative of the

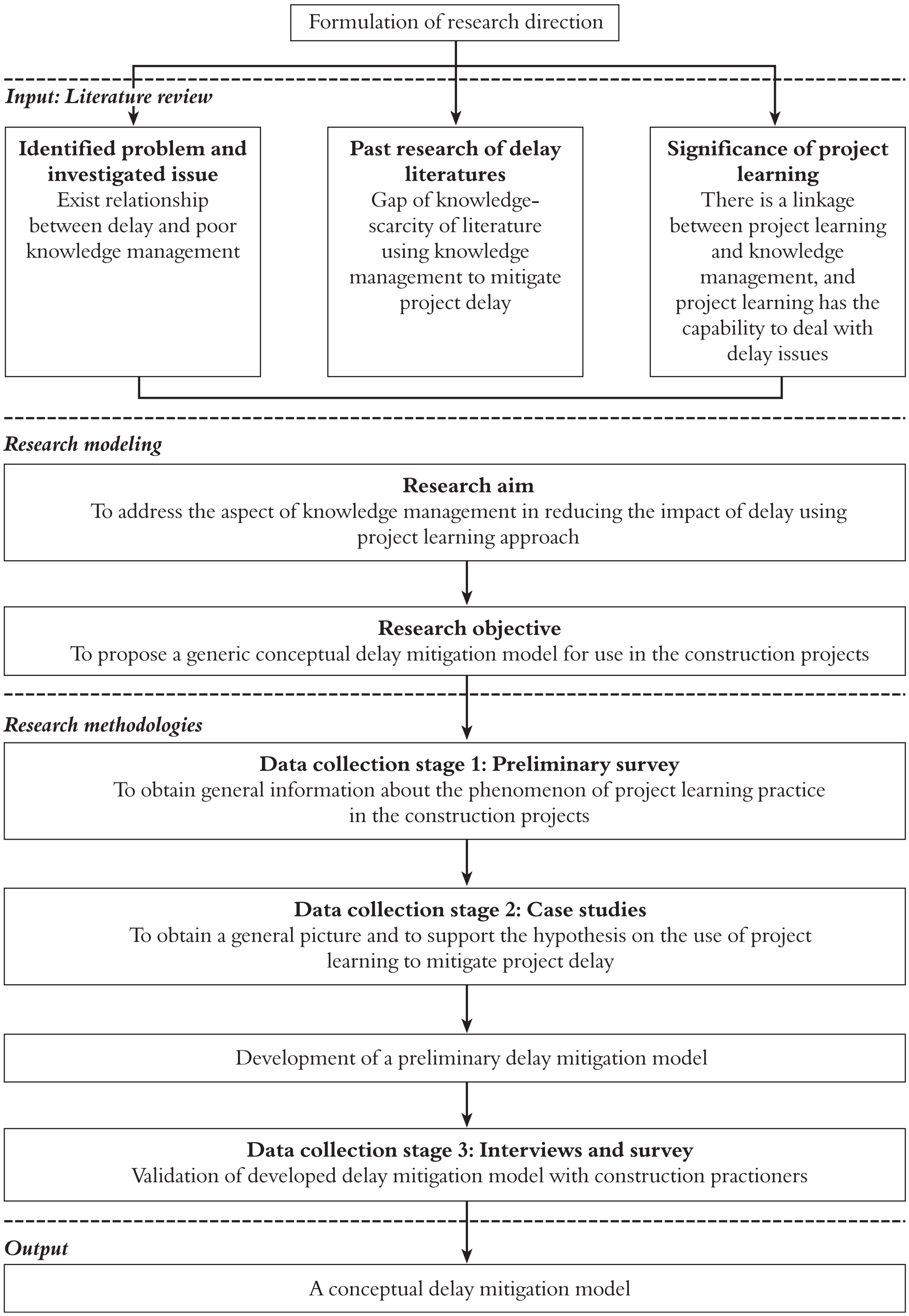


Figure 2 Analytical framework of the study

population owing to their involvement in various types of large scale construction projects. The sample was selected based on a simple random sampling method.

Semi-structured interviews were performed with 15 construction professionals from 12 contractor organizations for a period of five weeks from mid-May 2006.

Table 2 Construction Industry Development Board of Malaysia's contractors classification

Registration grade	Minimum paid up capital (RM)	Maximum project cost (RM)	Contractor categories (size)
Grade 1	5000	Not more than 100 000	Small
Grade 2	25 000	Not more than 500 000	Small
Grade 3	50 000	Not more than 1 000 000	Small
Grade 4	150 000	Not more than 3 000 000	Medium
Grade 5	250 000	Not more than 5 000 000	Medium
Grade 6	500 000	Not more than 10 000 000	Medium
Grade 7	750 000	No limit	Large

The purpose of semi-structured interviews was to obtain comprehensive data on the nature of the problem. Participants ranged from top management to technical personnel, including one general manager, two project directors, four project managers, one contract manager, six quantity surveyors and one planning engineer. Interviews ran between 35 and 120 minutes, and were conducted in a private and confidential one-to-one manner.

Questionnaire survey

A questionnaire survey was conducted to collect factual evidence about the importance of learning in the project environment. The survey was conducted over a period of two and half months from 13 December 2006 until 28 February 2007. The questionnaire was chosen to generalize findings from a sample to a finite population (Hammersley and Gomm, 2000). The questionnaire survey was targeted to the larger and more competitive groups of contractors, that is, those in the Grade 5, 6 and 7 categories. The study was based on a probability stratified sampling method to guarantee an adequate representation of groups (Weisberg and Bowen, 1977). A sample size of 2000 private-based contractor firms in Malaysia was empirically studied. This sample size is considered adequate based on the sample size table developed by Krejcie and Morgan (1970). The website and directory 2005/2006 of the Construction Industry Development Board (CIDB) was used as the sampling frame of the study. The sample size of the questionnaire was based on the following probability formula as suggested by Frankfort-Nachmias and Nachmias (1996, p. 186).

$$\frac{\mathrm{n}}{\mathrm{N}} = \frac{2000}{(2798+1028+3643)} = \frac{2000}{7469} = 0.27$$

where n=size of the sample; N=size of the population.

The questionnaire survey was administered by post and a covering letter was appended to explain the problem being investigated and the objectives of the study. Descriptive statistics were selected in analysing the quantitative data. Quantitative data were analysed using chi-square (Freund and Simon, 1997; Spiegel and Stephens, 1999; Freund and Wilson, 2003) through a computer program (SPSS 13.0).

Stage 2: case studies

Based on the nature of this study and the research method adopted by Fong (2003), three case studies were conducted using data from three Grade 7 construction companies registered with the Construction Industry Development Board (CIDB) of Malaysia. Data collection for the case studies, which were performed from December 2006 to April 2007, was aimed at obtaining a general picture of the implementation of project learning practices in mitigating project delay and to prove the hypothesis on the capability of project learning to mitigate project delay. Evidence in the case studies was drawn from two main sources, namely organization records and interviews.

Table 3 shows the general profiles of the projects covered in the case studies. Semi-structured interviews were conducted with those who had been involved in the whole project cycle, including project managers, quantity surveyors and engineers. All the interviewees have between five and 20 years of working experience. To gain more insight and information on the project learning practices, three different types of projects of which two had experienced delays and one completed on time, were chosen for the study. Data analysis was based on the within-case integration and cross-case comparisons. For the purpose of privacy protection to the case studies, identifiable information was displayed with anonymity requirements and project information was described in the general context.

Table 3 Project information

Profile details	Project A	Project B	Project C
Types of project	Shop offices	Hospital	Factory
Project location	Selangor, Malaysia	Melaka, Malaysia	Selangor, Malaysia
Source of project funds	Private funded	Government funded	Private funded
Project commencement			
Proposed	1 June 2005	16 October 2001	2 May 2006
Actual	1 June 2005	16 October 2001	2 May 2006
Project completion			
Proposed	30 November 2006	15 October 2003	1 November 2006
Actual	16 March 2007	8 April 2004	1 November 2006
Project cost			
Proposed	RM 19.3million	RM 78.6 million	RM 11.7 million
Actual	RM 19.1 million	RM 78.6 million	Not available
Method of procurement	Traditional procurement	Traditional procurement	Traditional procurement
Tendering arrangement	Open tendering	Negotiation	Open tendering
Type of tender	Bill of quantities	Bill of quantities	Bill of quantities

Stage 3: interviews and survey

The proposed conceptual model validation was performed through participative action research (Carr and Kemmis, 1986; Bordoli and Baldwin, 1998) with external third parties. The participative action research was conducted during April and May 2007 and engaged various practitioners in a collaborative process to refine and improve the proposed model. The selection of the practitioners was based on the following criteria:

(1) practitioners who have 10 years' experience and above in the construction industry; and
(2) practitioners who have 10 years' experience and above in the field of construction management.

Three project managers, four engineers and one site manager were involved in this part of the study. Direct interviews were conducted with four practitioners and another four practitioners were approached via a postal questionnaire survey. Among the participating practitioners, six practitioners had 20 years' experience and above in the construction industry and two practitioners had 10 years of work experience. The validation process looked into the following aspects:

(1) the techniques employed;
(2) the sequence of the model;
(3) the suitability of the methods in mitigating delay; and
(4) the applicability of the model in construction projects.

Feedback from subjects drawn from this study was later analysed to modify and adapt the best 'model' in an incremental improvement process. The passing of comments backwards and forwards led to iterative modifications and eventually the final presentation of the model.

Empirical findings

Stage 1: preliminary survey

In total, 180 completed questionnaires were returned. The units of analysis were mainly works as project managers (24.4%), directors (19.4%), quantity surveyors (17.2%), civil and structural engineers (14.4%), general managers (9.5%), contract managers (8.9%) and followed by 6.1% of respondents who held other positions. Approximately 75% of respondents have been engaged in the construction industry with a minimum of six years to a maximum 20 years of experience.

The findings of the preliminary questionnaire survey showed that more than half of the total respondents perceive that the learning issue is a subject of concern at three different levels of project environment. Referring to the frequency distribution in Table 4, inter-organizational level attained 94 (52.2%) of total respondents, intra-organizational level acquired 131 (72.8%) and personal level achieved 144 (80.0%). On other hand, findings of the preliminary interviews showed that:

(1) Face-to-face interaction and project meeting were the most common forms of collective learning among the project team members. This is because these two forms of learning methods are convenient and easy to hold and provide a good atmosphere of sharing and exchange of knowledge. Five interviewees further mentioned that face-to-face interaction and project meetings lead to an effective communication of storytelling.
(2) Four project learning enablers have been discovered as important elements throughout

Table 4 Frequency distribution of learning issue at three different levels

Level	Yes		Partly		No	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Inter-organizational level	94	52.2%	63	35.0%	23	12.8%
Chi-square=42.233; p<0.001 [a]						
Intraorganizational level	131	72.8%	49	27.2%	0	0.0%
Chi-square=37.356; p<0.001 [a]						
Personal level	144	80.0%	34	18.9%	2	1.1%
Chi-square=184.933; p<0.001 [a]						

Notes: [a] significance $p<0.05$.

the project cycle. The identified project learning enablers included environment, top management commitment, individual commitment and relationship.

(3) Among the 12 contractor organizations, one organization implements post project review to capture and store lessons learned, bad and good practices from construction projects.

(4) The reward system in terms of recognition and promotion persists as the customary means of retaining an individual's knowledge in construction organizations.

(5) All the interviewees agreed that project learning implementation could lead to the improvement of project schedule performance.

Based on the findings of the preliminary survey, it can be inferred that:

(1) Conservative learning, that is face-to-face human interaction, was widely used and accepted at the project level. This indicates that effective human interaction needs to be put into the consideration.

(2) Human-related elements are important in maintaining and managing learning processes.

(3) Knowledge gained throughout the project development is poorly managed in the construction projects. This is because organizations seldom recognize the importance of managing project knowledge in a systematic and secure manner although the majority of interviewees recognized that knowledge is a valuable asset in improving project performance. In other words, project knowledge was not given the right priority from the top management and many organizations resort to insecure means of managing knowledge by merely retaining the experienced personnel in organizations.

(4) It is observed that more than half of the respondents perceived that learning should be a subject of concern in the project environment.

Stage 2: case studies

Project A

Project A involved the construction and completion of three- to four-storey shop/offices. Industrialized Building System (IBS) of hollow core slab was selected for its slab construction. A feasibility study of IBS utilization was performed prior to the start of the construction stage. The results of the feasibility study showed that the use of IBS was not encouraging except for slab elements. However, project A experienced a delay for three and half months owing to discrepancies and late approval of hollow core slab drawings. Eventually, construction of slab was changed to the traditional approach to mitigate the impact of the delay event. The main delay factor was due to the lack of experience in IBS on the part of the contractor and the failure to incorporate learned experience and knowledge of previous projects into the feasibility study. The learned experience and knowledge included potential delay factors, non-technical problems and bad practices. In project A, project learning best practices were identified as follows:

(1) Before the beginning of each project activity, relevant lessons learned of bad and good work practices of previous projects were extracted from a knowledge portal system and passed to the relevant subcontractors. The learned knowledge contains information on the technical working methods to secure the performance of works.

(2) The contractor employed one experienced mechanical and electrical engineer and one experienced site agent with more than 30 years' experience on an annual contract basis.

(3) Learned mistakes from previous projects were used as a guide in decision making, for instance, planning on the sequence of project activities.

(4) Know-how and know-why were the type of knowledge shared during the project meeting and individual inquiries.

One of the significant bad practices of project learning was failure to integrate the knowledge of potential delay factors in decision making. The identified enablers and barriers of project learning included top management commitment, openness, and good and timely feedback.

Project B

Project B involved the design, construction, completion, equipping, commissioning and maintenance of a proposed 76-bed hospital. Project B represents a typical case in the current study as the project was contracted to a main contractor without any experience in hospital projects. The project has experienced delay of approximately half a year from the initial completion date.

Numerous factors contributed to the project delay. The two most significant delay factors were lack of experience and high staff turnover. Lack of experience has led to significant congestion of building, mechanical and electrical works during construction. To tackle the lack of experience problem the main contractor engaged two experienced site personnel, a project manager and a site supervisor, to share and utilize their past experience and knowledge in the construction of hospital projects to improve coordination and management of construction. High staff turnover was attributed to poor human relations and has wasted time in re-employing the relevant project parties. Poor human relations has produced weak teamwork and a poor network of knowledge sharing and learning between one worker and another. Poor practices of project learning that have been identified include:

(1) Few meetings were held among the project parties to discuss problems and to share and exchange knowledge during the preconstruction stage.
(2) The contractor did not prioritize and use mistakes learned from previous completed projects.
(3) Top management was very sensitive on the term ‘mistakes’ which has inhibited effective inter-project learning.
(4) Lessons learned from the project were not captured and stored for the benefit of future construction projects.

Among the best practices of project learning identified include:

(1) adopting inter-project learning by engaging experienced construction professionals in the field of hospital projects;
(2) increasing the frequency of project meetings during the construction stage of the project.

It is apparent that the enablers and barriers of project learning include human relationships, top management commitment, individual commitment, teamwork and openness.

Project C

Project C involved the construction and completion of new dies manufacturing plant. Project C is considered a successful project as the project was successfully completed on time. The best practices of project learning identified include:

(1) Learned knowledge from previous projects in terms of mistakes, bad and good practice was disseminated by engineers and the project manager to relevant project parties in the form of informal face-to-face interaction before the start of a particular project activity.
(2) Learned mistakes from previous projects were used as a guide in decision making, for instance, the planning of project activities.
(3) Experienced experts in steel and structural engineering were engaged to bring in their knowledge to deal with the steel frame of the building structure and the incorporation of building elements.

In this project, it was notified that lessons learned from the project’s problems and critical events were not properly disseminated, captured and stored in a systematic approach for the benefit of future construction projects. Enablers and barriers of project learning comprised continuous and open communication, individual and top management commitment, and equity.

Stage 3: interviews and survey

In general, comments from the practitioners on the conceptual delay mitigation model were as follows:

(1) The processes involved in the model and the specified enablers and barriers of project learning are considered suitable and important for the problem being addressed.
(2) The practitioners commented that the sequence of the model is understandable and logical.
(3) All the practitioners concurred in view that the use of project learning could help to mitigate the problem of inadequate contractor experience and that project learning can improve project time performance. However, some practitioners provided additional comments on the concept of project learning. These included: (a) the use of project learning to mitigate project delay can be extended and

focused on the organizational policy; (b) the use of project learning should not be limited to technical project knowledge but should be considered non-technical knowledge of mitigating a delay event, (c) a systematic and user friendly system is important to capture the lesson learning during the project period; (d) good resource planning and a systematic flow of lesson learning during the planning stage are important in construction to prevent delay events.

(4) The model is considered applicable in the construction projects.

Discussion and analysis

Based on the findings and observations, project learning contributes considerable positive impact on the project schedule performance. The main hypothesis of the study is supported where the use of project learning could assist project parties to mitigate delay events. In addition, learning is considered an important issue in the project environment at the inter-organizational, intra-organizational and individual levels.

A corollary to the above findings is that despite knowledge being perceived as an indispensable component of the project performance, project knowledge gained over the years is not properly managed or prioritized by top management. This example of bad practice illustrates the importance of employers and project parties to take the right and timely action and to be aware of the possible consequences if the problem is not solved in the next project. Moreover, much time and expense could be saved if top management gives full priority to the lesson learned knowledge of the project. Employment of experienced personnel seems to be the preferred method of a majority of contractors to secure project performance. Lack of consideration on the issue of staff turnover or loss of knowledgeable personnel could have a significant impact on the project time performance. A knowledge storage system becomes the main source of tackling the project and decision making in the event of loss of experienced personnel.

Human interaction is perceived as an important element of performing an effective process of project learning. Top management commitment, individual commitment and human network relationships are critical components to drive an effective project learning process. The results of the preliminary survey and case studies showed that commitment from top management and individuals are critical in the creation of an effective 'learning mood' in construction. In response to the importance of human elements in project learning, proper formal and informal supervisory controls to secure effective interactive communication, both human to human and human to technology, are essential. Moreover, supervisory control is necessary in ensuring project learning can be implemented in an effective manner.

Conceptual framework of the delay mitigation model

Drawing on the results and the analysis of the data discussed in the previous sections, the study proposes a conceptual based delay mitigation model as shown in Figure 3. The delay mitigation model is designed specifically for use in construction projects and with an intention to deal with major delay factors caused by lack of knowledge and poor management of lessons learned. To ensure an effective project learning process throughout the project period, project manager, engineer or experienced personnel should act as a project learning supervisor to ensure all project activities are performed in a knowledge-based manner.

Processes of delay mitigation model

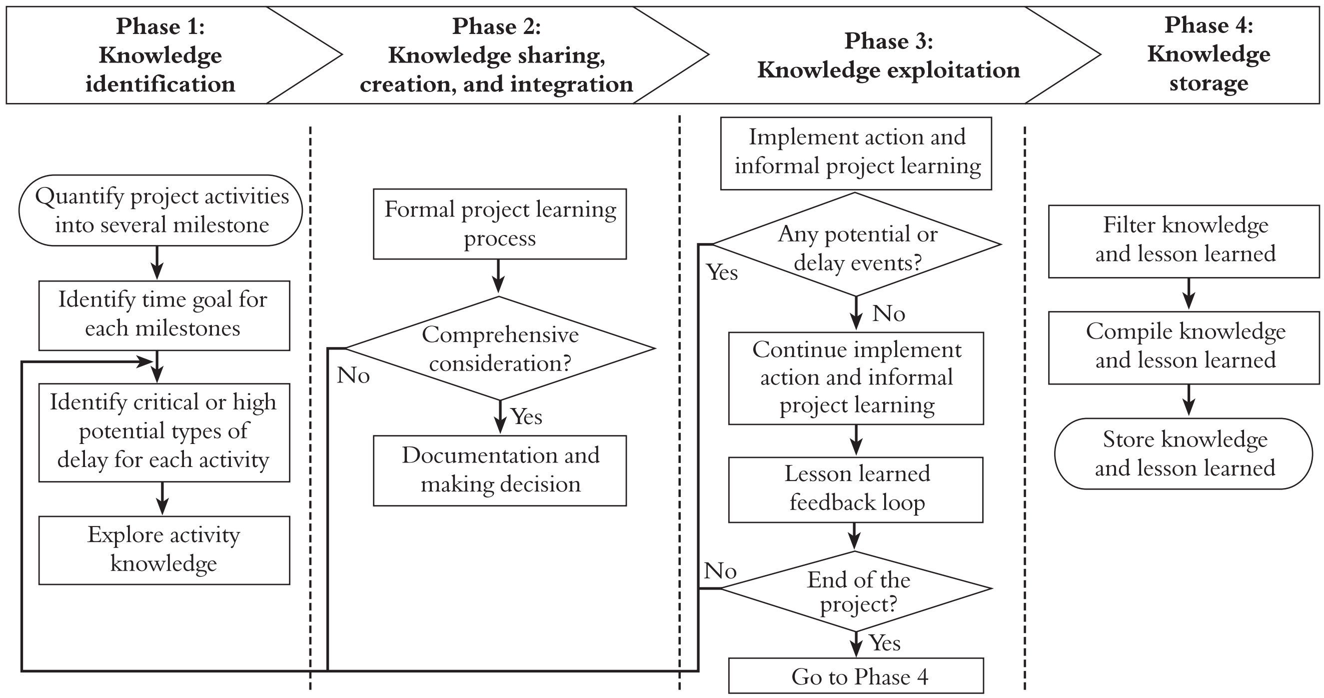
The proposed model consists of four main phases. Each phase contains enablers and barriers of project learning which have been accumulated and gathered from the case studies as illustrated in Figure 3. The processes of the model are briefly elucidated in the following section.

Phase 1: knowledge identification

The focal point of knowledge identification is to quantify project activities into several milestones with a time goal for each milestone. These activities are based on the characteristics of the project in terms of size, complexity and so on. Based on the identified critical or potential types and causes of delay, each milestone should be further explored and classified into five important components as shown in Table 5.

Phase 2: knowledge sharing, creation and integration

Formal project learning meetings should be held between a few key/experienced personnel from each organization. The formal project learning meeting must be concerned about the discussion of problems, searching for solutions, sharing and exchange of learned mistakes, knowledge and experience. It should be ensured that the outcome of the project learning meeting is to enable integration of the available knowledge to form a new knowledge on how to mitigate delay. The frequency of organizing a project



Project stages	Preconstruction and construction stage	Construction stage	Near the project completion stage
Enablers	Continuous individual commitment, continuous top management commitment, continuous inductive environment, continuous human network, continuous open communication, teamwork, equity	Continuous individual commitment, continuous top management commitment, continuous inductive environment, continuous human network, continuous open communication, active, opportune feedback	Continuous individual commitment, continuous top management commitment, openness
Barriers	Poor commitment, adversarial relationship, individualism, discrimination	Poor commitment, poor teamwork, lack of observance	Discontinuous commitment, conceal

Figure 3 Delay mitigation model using project learning

learning meeting depends on the types of problems faced, the complexity of the problem and the accessibility of the knowledge content.

Generalization using real life case studies is encouraged as project parties can easily establish linkage or connection between current and previous completed projects. During the meeting, multi-way feedback should be performed to improve the quality of new knowledge and solutions. Relevant and important information and knowledge should be properly documented for the purpose of retrieving and referring. Examination of the project learning meeting should be conducted to ensure that no important elements have been overlooked which might have a negative impact on project schedule performance prior to the finalization of the decision.

Phase 3: knowledge exploitation

When performing the project activity, it is important for relevant project parties explore the action taken in respect of the impact of the action taken on subsequent

Table 5 Components of knowledge identification milestones

Components of knowledge	Description
1. Knowledge content	Bodies of knowledge that are essential to complete a particular milestone within specified time goal
2. Knowledge gaps	Differences between the knowledge content and the actual knowledge available
3. Knowledge risks	Risk associated with accessing of knowledge content, knowledge gap and alternative knowledge
4. Alternative knowledge	Knowledge that offers greater possibility to supersede the core knowledge
5. Knowledge source	People, previous project documents of the knowledge content

activities and time performance. To exploit knowledge during the construction stage of the project, project parties need to track down potential problems, critical events and potential solutions which can affect the project time goal. Any learned mistakes, learned knowledge and principles of problem solving should be incorporated into the feedback report, attached to the project progress report and disseminated to project parties to form a real time feedback loop. A real time feedback loop ensures that other project parties are well informed, similar mistakes do not occur on the subsequent task, and it enables better informed decisions to be made for subsequent project activities.

Phase 4: knowledge storage

At the end of the project, knowledge gained throughout the project period must be filtered, compiled and stored in a standard template. The standard template should composed of milestone, action taken, types of delay, delay factors, learned mistake, bad practice, good practice, and critical learned knowledge. These actions aim to avoid loss of valuable knowledge for reference in future projects and to minimize the problem of information overload.

Strength and limitation of the proposed conceptual model

The strength of the model is the use of project knowledge to improve delay factors due to lack of knowledge that will lead to the increase of time in searching for relevant knowledge, reinventing the wheel or other potential problems that can affect the time performance. The potential shortcomings of this model are: (1) it is built on an unproved premise; (2) it is difficult to ensure accurate knowledge is disseminated during the project period; (3) the model requires experienced personnel to perform the supervisory control; and (4) the process of the model tends to cause overload of information especially in large and complex projects.

Conclusions

Poor management of project knowledge in the construction industry encourages difficulty of access to valuable and quality knowledge in performing project tasks. This in turn will lead to repeated mistakes, slow and wrong decision making, and as a consequence, it will lead to an increase in time and delay events. Case study findings showed that although the use of project learning practice cannot totally solve the delay event, the application of project learning practice in construction projects could prevent future project delay. The application of project learning thus should be managed with due care and due diligence to grasp the maximum value of project learning.

The research has implications for both practitioners and academic researchers. For practitioners, this study highlights the importance of project learning to improve the level of competency of contractors for future projects. For academic researchers, there is a need to highlight and draw the practitioners' attention to the significance of project learning in the development of project performance competency. In addition, there is a need for researchers to look beyond the construction project delay factors and employ a more comprehensive and practical approach to deal with the critical delay factors.

It is suggested that further research on the proposed model be conducted as action research on a few selected construction projects. Such research can improve the proposed delay mitigation model and provide knowledge in field of delay mitigation. As human elements play a critical role in the areas of knowledge and learning, leadership and professional ethics serve as springboard for future studies on mitigating construction project delay using the project learning approach.

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