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Impact of Manager's Role and Information and Communication Technologies (ICT) on the Construction Projects

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Abstract: The multifaceted responsibilities of the project managers substantially affect the success of the project. Increased attention is drawn on the use of information and communication technology (ICT) for leveraging the success of the construction projects. Thereby, this study aimed to assess factors affecting shared knowledge and performance in construction projects in the Kingdom of Bahrain. Both qualitative and quantitative analysis was carried out to collect data. Firstly, interviews were conducted to collect qualitative data from both engineers and project managers. Secondly, questionnaires were distributed among the sample to evaluate the quantitative data. The results showed that the project managers view shared knowledge in two aspects, i.e., information availability and individual skills. Level of education, the existence of protective individuals, communication ability, and knowledge and skills were found to be the factors affecting knowledge sharing. ICTs were also found to help managers and engineers in administrative tasks.

Keywords: Bahrain; Construction Projects; Information and Communication Technologies (ICT); Knowledge Sharing; Project Managers; Shared Knowledge.

1. INTRODUCTION

Organizations during the normal course of business practice face many difficulties. Senior management must implement decisions to achieve drawn strategies. However, serious consequences can accompany these decisions. Reliance on individuals' knowledge in dealing with these difficulties exposes organizations to great risks. Organizations need to find solutions based on collective knowledge and action. Collective knowledge and skills of a team are expected to lead to safer and superior results. Thus, project teams were exploited as an effective utilization of experts from various specialties for solving sophisticated problems that cannot be solved by an individual.

A project, as defined by [1], is "A temporary endeavour undertaken to create a unique product or service." Projects are the well-defined set of aimed end outcomes that are achieved as a one-time activity. This activity is complex and usually divided up into sub-tasks that are coordinated and controlled in a specific way. Primarily, projects depend on the group of individuals and their diverse personal skills, which directs them to a single goal. Composing teams in projects helps to resolve problems, however when it has become a problem in itself, it requires a solution. Managing these teams in a project structure, which are often separated from the organization's structure hierarchy, is a challenging process. Moreover, an implicit challenge in this process is to manage a critical strategic resource for projects, i.e., knowledge. Knowledge is an important strategic resource for the success of projects of organizations, and managing it is necessary for the organization's success [2, 3]. Generally, project management is defined as the application of the skills, knowledge, tools, and techniques for performing project activities [4]. Whereas, successful project management refers to the effective and efficient management of the tasks, tools, resources as well as activities [5].

Studies provided different definitions of successful project management [5-7]. Such as empirical research of Bannerman et al. [5] indicates that project success refers to its timely completion within budget and as per the specification. Todorović et al. [6] writes that it occurs in the form of project completion, produced product success and achievement of the project objectives. While Demirkesen states that the project success perception varies as per the project stakeholder [7], however, these may vary based on time and expanding knowledge base.

Recurring challenges continue to occur in the construction projects, which necessitates that project managers must comprise the competent skill set. This helps managers promptly devising timely decisions [8]. Also, managers integrate all the components necessary for successful project delivery. Several studies show that

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managers' skill set is accounted for the success and failure of the project [8-11]. For instance, a project manager is required to possess human, technical, and conceptual skills for ensuring the successful completion of the project. The manager is required to understand his role and convincingly guide others, as the inability to do so can lead to cost overruns or delays. Turner [10] also suggests that for ensuring the success of construction projects, the manager must examine the factors in its success months or years to identify the success factors that can be deployed in other cases as well. Bryde et al. [11] write that managers' contribution to the cost reduction of the project is integral for effective project completion. However, the inability of the project manager to devise accurate or correct decisions can lead to substantial loss, cost overrun, and delayed completion resulting in project failure.

To ensure that effective measures are adopted, various project management techniques can be deployed, including the work breakdown structure, Program Evaluation, and Review Technique (PERT), as well as Gantt chart [12]. Critical Path Method (CPM) is another technique where the scheduled tasks are presented using different time computing methods. It is tasked parallel to each other, where a similar task can be performed. Whereas, the PERT and Gantt chart are manually prepared. Often PERT and CPM are interchangeably used with benefits, including the activities planning and scheduling, projected resource requirements, and rescheduling when necessary.

Methods and approaches for measuring shared knowledge may vary. The study focuses on measuring team-level knowledge, rather than organization-level knowledge, which has been the concern of many business researchers. This demands to examine the Shared Mental Model (SMM) of the individuals in a team which is deemed to be the place where knowledge is stored in organized, structured and meaningful patterns [3, 13, 14]. Thus, SMM helps individuals to describe, explain, and predict events in their environment [15]. Teams possess an overlapped knowledge, which is referred to as shared knowledge, resulting from previous experiences obtained through study or work. This knowledge may often converge or diverge, resulting in a direct or indirect impact on the collective performance of a team [16, 17]. From a project-oriented view, shared knowledge is either task-related or team-related; both types were found having a relationship with the performance of teams either in the beginning or at the late stages of a project life cycle [18]. This stimulates researchers to study each type as a separate construct. There is a close relationship between task and team related knowledge, where one affects the other, either negatively or positively [19].

It is well established by the studies that employees show resistance towards adaptation of information technology [20]. Despite the well recognition of the Information and Communication Technologies (ICT) technology, its adaptation is relatively low as compared to other sectors [21, 22]. The research of [20] highlight that technology adaptation in the construction sector can be overcome by the managers who act as a catalyst for the proliferation of technology adoption. [21] concluded that ICT adaptation is limited due to two factors, namely, technological problems and coordination problems. The limitation to the exploration of the behavioural related factor has also been highlighted by an earlier study of [23]. These findings highlight that behavioural attributes of the managers are integral for understanding the information sharing in the construction projects. The personal and behaviour attributes of the managers are also identified by various studies highlighting its role for the success of the ICT adaptation [22, 24]. These studies further highlight the factors such as leadership, trust, and reciprocity to impact the knowledge sharing among the workers. The study, therefore, focuses on recognizing the factors and the role instigated by the managers for the ICT adaptation and its progress in the construction sector. Reference [25] depicts that these findings will help in developing the absorptive capacity of the construction workers to respond to the emerging and new project needs in an integrative manner.

Before starting any project, a huge effort is invested in its planning [26]. Planning is the basis for developing the budget and schedule for work. It involves defining and identifying the interaction between the work tasks, estimating required resources, estimating the duration of each task, and choosing the proper technology. Projects are governed by specific mechanisms to ensure quality and achieve their financial and time goals. Construction projects comprised of several role players depending on the project sizes [26]. Starting with the owner, who invest in the project either by funding, facility or both and ending with the contractor and sub-contractor, who implement the very specific and detailed tasks in a project. Clients hire one or more representatives to act on behalf of them with the contractor. These representatives either a consultant that designs the building to the requirements of the client and supervises the contractor's work and/or quantity surveyor, who ensures the value and material quantities of the completed work. The focus here is on the contractor of the project. The contractor's team is assigned to supervise and execute the construction work. The reason for choosing this role player to be the domain of the study is the feasibility of obtaining performance measures for the task accomplished by their teams.

This paper aims to examine some factors at the team member level and explain their relationship to the performance of their teams. The study focuses on team level factors such as general team and task knowledge, communication skills, attitudes toward team and task, team dynamism, and working environment. The influence of shared knowledge on the performance of teams has already been explored in the literature, but most of the research was conducted in non-naturalistic settings such as university student courses [27]. This study attempts to examine the

influence of real project-driven companies, which are working on knowledge-intensive construction projects. Such empirical study contributes to project-driven organizations by improving team training programs and the design of knowledge aiding technologies. The study also tries to qualitatively evaluate project managers' role and the contribution of Information and Communication Technologies (ICT) in the construction process.

In the following paper, section two provides a review of the previous researches, while section three presents the theoretical model and hypothesis formulated for this study. Section four of the paper presents the methods used in the article, following which section five provides the results and discussion. Lastly, section six of the paper concludes the findings drawn and presents future research considerations.

2. LITERATURE REVIEW

A. Shared Knowledge and Mental Models

Shared knowledge refers to the cognition shared among communicating parties. Sharing can mean different things, depending on the context within which it is described. It can refer to "dividing up" or "having in common." Whereas, in teamwork, knowledge can be divided between teammates, which form a compatible state, where teammates hold compatible models (role-specific knowledge) that lead to common expectations [28]. Earlier work by [29] provided that the mental models of the team members are interconnected with the abilities of the team members. This ability improves the individual's prediction in terms of future incidents, improve cooperation as well as provides them with insights into the knowledge which the team as a whole withholds.

Two forms of shared knowledge can be distinguished from the literature according to its direct relation to either the task or the team members. Task-related knowledge is common knowledge about the processes that relate to a task. Such knowledge can contribute to the team's ability to accomplish a variety of similar tasks within a specific field [30]. The previous study by [31] demonstrated that Team-related knowledge relates directly to the understanding of fellow team members. It includes their preferences, strengths, weaknesses, and tendencies.

One way that management researchers understand knowledge is as tacit know-how that is embedded in organizational skills and routines [32-34]. Knowledge is deemed to be an intangible accumulated resource that increases or maintains the sustainable competitive advantage for an organization from the business perspective, which looks at the organization as a single entity [35-41].

Research into organizational behaviour and psychology refers to the knowledge (cognition) that an individual brings to a situation related to a task or a team as mental models (MM). Considering the cognitive aspect of knowledge sharing, it is suggested that the individual mental model is dependent upon his practical exposure, i.e., the things he has experienced and witnessed. The learned mental concepts rarely used as in the real environmental setting, the individual previous actions and interactions serve as a base for his creation of mental models [42]. This collection of models includes rich content about tasks, equipment, working relationships, and situations [29, 43, 44]. This reference to the knowledge of individuals as mental models shows the important contribution of the knowledge of workers to their employing organizations. Previous research by [28] further extended the range of shared mental models beyond teammates and tasks to the working environment, where they assumed these models are members shared and required organized collaborative understanding and representations of knowledge about key elements of the team's relevant environment.

Knowledge workers are defined as high-level employees who use theoretical and analytical knowledge as a dominant aspect of their work in producing a final product [45-47]. This knowledge is acquired through formal education or informal sources of education, such as experience in a specific field, previous access, and application of personal knowledge, organizational knowledge and external knowledge [46, 47].

B. Measuring Shared Knowledge

Methods and approaches for measuring shared mental models (SMM) vary and have been discussed in the literature. The dominant methods are elicitation, team-metrics, and aggregation methods [48]. Elicitation methods attempt to capture the richness of the knowledge itself. These methods will examine the content and the structure of the individual or team's knowledge. Elicitation can be conducted through observation, interviews and surveys, process tracing, and/or conceptualization methods. Team-metrics methods are meant to quantify the qualitative data and structure of elicited knowledge. This will allow the researcher to assess knowledge accuracy easily, aggregate individual results to generate a representation of a team's knowledge, and compare individual results within teams to assess the similarity of knowledge [28]. Aggregation methods use the elicited data and metrics to aggregate or average individual data by team. Although most of the researchers averaged individual data, there is a risk in generalizing the results due to team-member variance.

C. Shared Knowledge and Project Performance

Several studies supported the positive relationship between shared knowledge and team/project performance in different settings and disciplines [49]. The statement is supported by the study of [50], which provides that knowledge sharing is responsible for improving team performance. This enhancement, according to the mentioned study, is based on the effective and improved decision-making capability of the team members. Prior work by [18] concluded that in the learning environment,

team-related knowledge has a strong correlation with performance on the team and individual levels in the early stages of the project. However, the study found that it starts to fade out towards the late stages of the project; whereas, task-related knowledge correlation with the performance starts strengthening towards the end. The similarity in a team's attitude toward their tasks or teammates affects the performance of the team negatively in complex projects because of the gap in the diversity of perspectives.

Preliminary work of Patnayakuni, Rai, and Tiwana [51] also highlights that the improvement in team performance is based on its knowledge sharing practices. It investigated the knowledge sharing practice in team members operating in the firm information system. The outcomes of the study showed that the increased knowledge integration leads to better performance of the team members. Similarly, the previous research by [52] presented a discussion on the literature related to shared knowledge effectiveness and its impact on the processes and performance of virtual teams. The study proposed a conceptual model of this impact, adapted from the literature. The study also posited four main propositions, divided into twelve sub-propositions, derived from their model.

The study analysed and supported the propositions using prior literature, anecdotal evidence, and qualitative data from case studies. It concluded that there is a potential positive impact of shared knowledge on performance; although, virtual interaction is mainly focused on considering the team interaction. In the same context, [17] examined data that appeared in members' e-mails for some time. This data could be general to a team or specific to tasks. Their study captured overlapping keywords in the content of the e-mails, which it claimed represented the level of shared knowledge in a team. It concluded that there is a non-linear relationship between shared knowledge and team performance. This suggests that the existence of a healthy amount of knowledge overlap among teammates contributes to performance, where too much or too little mutual information could impede the team's performance.

D. ICT Contribution in Construction Projects

The proper use of ICT synergizes efforts to achieve goals as illustrated in [53] and [54]. Use of ICTs contributes to the process of providing services through reliable methods, which help in efficiently storing, retrieving and presenting information in terms of time and space, consistency and accuracy of records, flexibility while maintaining security, and integration of different functions [55]. A positive association of ICT use with the performance was evidenced in [56] study. The study showed that ICT use increases the productivity of workers. At the communication level, ICT use was deemed as a key success factor for virtual group communication because it keeps members connected by distributing information among them [52].

From a Knowledge Management (KM) perspective, ICT is considered as an enabler for managing organizational knowledge. ICT provides the capabilities of facilitating conversations between people to create new knowledge or reuse codified knowledge [57]. These capabilities, according to [49], include the allowance for creating, sharing, storing, and using knowledge. The previous research by [58] evaluated the knowledge sharing management, which used the ICT technology within the virtual organization, which comprises of four organizations of Taiwanese NGOs in the Chinese cultural context. The study surveyed 131 employees who work in the particular virtual firms. It applied the Structural Equation Modelling (SEM) which showed that the support provided to the employees with the use of ICT services in the firm was able to overcome the gap that remained in their accomplishment of well-being sense, as well as the culture which is practiced in the organization along with overcoming the obstacles of the knowledge-sharing behaviour.

This research provided a profound analysis of the knowledge management practices as well as the behaviour practiced by the employees, which all contribute to the enhancement of the employee's sense of well-being. Therefore, some organizations provide a space for informal channels to take place between teams [59]. It is well established by the study of [60] that Instant Messaging (IM) tools empower members by shaping the social networks and facilitating knowledge sharing in teams.

3. THEORY, MODEL, AND HYPOTHESES

Various theoretical work has been conceptualized around the concept of performance enhancement of the firm and projects. Such as earlier work of [61] demonstrated around 29 frameworks where an overlap of the models can be observed. However, teamwork was the factor that was agreed upon each framework where various observation and measurable aspects were highlighted. Such as, a study by [62] and [61] showed that teamwork has 10 and 14 dimensions, respectively. Though, the general analysis highlighted that managers were observed as the main players who affect it and its associated performance. This is well recognized by the father of group dynamics [63].

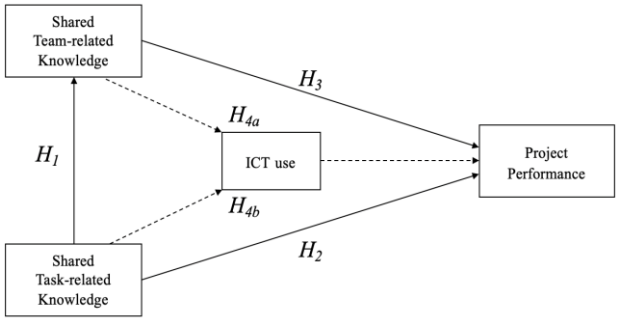

Figure 1. Research model.

The presented framework theoretically contributes in various ways. Such as it serves as a roadmap for the researchers who intend to contribute to the development of the theoretical practices related to the project development, particularly in developing countries. Since the formulated framework is generic; therefore, it offers opportunities to extend the research concerning the construction context and incorporate contextual variables. Such as it promotes the use of existing theories for describing the relationship between the behaviour and the transition economies in the construction context [64].

This research model is based on dynamic mutual cognition among team members who work on a project, and relationship between shared knowledge and performance. The model aims to understand the effect of variables related to the task, communication skills, attitude, dynamism, and environment of a project team on performance (Figure 1).

Prior researchers' findings indicate that task-related knowledge has a positive influence on performance by reducing communication between team members while performing a task. This allows them to concentrate their mental energy on the task [19]. This research model proposes that task-related knowledge has a positive effect on both team-related knowledge and team performance, and therefore the following hypotheses can be generated:

H_1: Shared Task-related knowledge is positively related to Shared Team-related knowledge.

H_2: Shared Task-related knowledge is positively related to project performance.

As explained earlier in the literature review, team-related shared knowledge contains similarity in the knowledge of communication skills, attitude toward team or task, and dynamism, in addition to the environmental factors that surround the team. In complex projects, the knowledge diversity increases the performance of a team [17, 86]. Thus, the similarity in a team's attitude toward their tasks or teammates affects the performance of the team negatively in complex projects because of the lack in diversity of perspectives. Hence, the following hypothesis can be generated:

H_3: Shared Team-related knowledge is negatively related to project performance.

Considering the contribution of ICT in construction project management, it is considered that ICT plays an essential mediating role in performing project tasks and sharing knowledge (the dashed lines in Figure 1). Hence, it is proposing to study the indirect effect of shared knowledge on performance through introducing ICT use as a mediating factor in the future, and hypotheses are formed as:

H_{4a}: ICT use will mediate the relationship between Shared team-related knowledge and project performance.

H_{4b}: ICT use will mediate the relationship between Shared task-related knowledge and project performance.

A. Study Context and Settings

Since the beginning of the political reform in 2002, the Kingdom of Bahrain had witnessed a noticeable increase in the number and type of construction projects. Many foreign and Arab capital investments were infused in the kingdom. Although the development slowed down after the arising of the global financial crisis in late 2008, the majority of projects continued to operate till completion. To explore and understand the relationships in question, the current study was conducted in a knowledge-intensive project environment such as Bahrain's construction industry. Companies were selected based on their project sizes and having a well-established project management and quality control systems, which will help provide quality input data for the research. These companies were engaged in different types of construction projects, such as industrial structures, infrastructure development, prestigious towers, jetties and quay walls, drainage pipelines, land reclamation, and offshore works.

The companies have teams of project managers, engineers, technicians, and skilled and unskilled workers, and utilizes the standard and latest construction methods and machinery for their projects. The number of teams and team members involved in a project depends on the project size. See Appendix A for an illustration of the typical construction project structure. The turnover rate in the construction sector, especially in Bahrain, is high. Once a project contract is finished, some engineers and supervisors leave the company or the country. This makes it difficult to trace staff who worked on completed projects to participate in the quantitative part of this study. However, many of the former engineers were contacted through e-mails to obtain their feedback.

Every project has its own management office that is located on-site; this office works somehow as a separate entity from the parent company. Project managers delegate the work to departments created in the mobilization stage of the project. These departments are usually planning, engineering, commercial, quality control, safety, health and environment control, and document control departments. All documentation and reports are kept in this office during the project lifetime; then, it is transferred to the headquarters premises at the end of the project.

According to the size and area of the project, some may require having more than one office within the site to ease the supervising process of engineers over the progress of work. Communication in this layout is very important. However, it is mostly done through face-to-face contact through daily morning meetings at the main site office. There are many opportunities to exploit ICT to connect and maintain electronic communication between these offices, yet some obstructions are there, such as budget and resource priorities. In addition, the expenditure on such technologies in a temporary kind of project is not justified for some project managers.

4. Material and Methods

This research both qualitative and quantitative approaches. The qualitative approach was used to understand the structure and processes of contracting projects in construction companies. The quantitative approach was used to obtain data about shared knowledge from knowledge workers (project managers, engineers, quantity surveyors, document controllers, and supervisors) on project teams.

A. Qualitative Data Collection

In-depth interviews were conducted (some were tape-recorded) with experienced project managers and engineers. A structured interview technique was used to minimize bias. A set of fixed, structured questions was read out to each interviewee, and the same was adapted to interview other knowledge workers. The questions that were asked include the managers' main role, the principles followed, and the applied monitoring and supervising procedures. The daily activities of the project managers were also asked.

Four project managers and one engineer were interviewed. The participation in interviews was completely voluntary. Procedures were explained to each interviewee before commencing the interview. Participant information sheets, explaining the aim of the study and its involvement, confidentiality, and withdrawal procedures, were given to participants to read first. The duration of the interview ranged from 20 to 60 minutes.

B. Quantitative Data Collection

The primary quantitative data, shared knowledge measure, was collected through questionnaires, and the project performance was obtained from company records. In the present study, an instrument developed by [31] was used to gather data from project teams. In it, the questionnaire items were 44, which were divided into five sections. This includes general task and team knowledge, general task and communication skills, task and team dynamics as well as team interaction, resources, and the work environment, with established content validity.

Following it, members of a team were asked to give their perception about their teamwork experience using a five-point Likert rating scale (where 1 was equal to "strongly disagree" and 5 "strongly agree"). The degree of shared knowledge (overlapping) within a team is calculated by aggregating the means obtained from members' ratings. The instrument was used to elicit shared perceptions of typical kinds of projects, which usually have a common lifecycle or process (planning and designing, implementation, and evaluation). Thus, it is believed that the instrument would produce the same adequate reliability and validity of measures. The instrument consists of 42 questions grouped into 6 groups (General Team-related Knowledge, Team-related Communication Skills, Team-related Attitude, Team-related Dynamism, Team-related Working Environment, and General Task-related Knowledge). Every group is treated as a unit in the analysis.

In project-structure companies, an appropriate way to measure project performance is to base it on three key project success indicators; scope, time, and cost. Since the selected companies have well-established record-keeping systems for projects and performance, the study is sought to obtain each project's status in terms of budget and time. The study has obtained the number of non-conformance reports (NCRs) and safety incidents reports as a measure for the quality of the projects. The delay in project delivery dates was obtained as a measure for project time performance. Meeting the profit margin was also obtained from records. The study has found that the delay in project delivery dates was a proper, objective, and reliable measure to identify project performance. Project delays were derived by subtracting original contracted delivery dates from actual delivery dates of projects. Some companies tried to justify the delays, orally, by attributing it to uncontrolled factors such as material unavailability or clients' changes. However, in both cases, it is the project manager's responsibility to ensure proper planning for material and well management of changes, which are all related to the performance of the project.

A convenience sample was used. Projects and companies were selected based on the convenience of accessing their working sites/premises and project information. However, the following criteria were considered in the selection:

- A company operates in the construction field.
- A company has a well-established quality control system.
- A company has proper record-keeping systems for its projects.
- A project has a value of US$2.6 million or above, to ensure that projects are large enough.
- A project has to be completed during the past two years at most.

The study was able to invite and acquire data from five construction companies. The members working in these companies were assured that their response was voluntary and that their responses would be kept confidential and used only for research purposes. One hundred twenty-one complete and valid responses were obtained from 15 projects. Two projects were excluded due to quality impairment - the researcher had no control over the procedure of collection. Response rates per project are shown in Table I. The questionnaire's internal consistency was tested using Cronbach Alpha reliability test. The test showed adequate reliability. Values ranged from 0.72 to 0.85 except for one variable; it received 0.61.

TABLE I. Response Rate per Project

Project Code	No. of Project Members	No. of Responses	Response Rate
Project 1	8	6	75%

Project Code	No. of Project Members	No. of Responses	Response Rate
Project 2	10	10	100%
Project 3	12	7	58%
Project 4	3	3	100%
Project 5	7	4	57%
Project 6	13	9	69%
Project 7	6	5	83%
Project 8	5	5	100%
Project 9	10	8	80%
Project 10	11	10	91%
Project 11	10	8	80%
Project 12	36	24	67%
Project 13	11	9	82%
Project 14	4	4	100%
Project 15	9	9	100%
Total	**155**	**121**	**78%**

5. Results and Discussion

From the qualitative data gathered through interviews and site observations, project managers confirmed their main role is to plan and layout the general principles for the construction process [65]. The results also highlight their role in supervising and monitoring the work to reach the ultimate goal [66]. Interviewed project managers were asked to talk about their daily activities. The following is an aggregation of all activities described. These activities do not follow a sequence; some can be done in parallel with others. Note that different engineers and other knowledge workers are involved in these activities.

- Study the contract, including specification and drawings, and get agreement on the project methodology.
- Ensure all legal requirements are in places such as complying with local regulation of permits, safety, environment, and other specific requirements.
- Conduct risk assessment and analysis.
- Plan for project aspects such as technical, budget, quality control, procurement, health, and environment control, etc.
- Develop the program (schedule) to determine how long it will take to complete the contracted work.
- Decide the size of the workforce required, level of supervision, the chain of command, materials, and equipment required, and communication system.
- Delegate tasks to subordinates (commercial team, technical team, field team, etc.).
- Monitor schedules and progress using project management tools.

A. Problems Faced by Construction Projects

Although the projects understudy work in the same industry, every project has its own problems. In this section, some of the problems that project managers believe are important in the Middle East and must be dealt with care are demonstrated.

- Difficulties in accessing and delivering material to the construction site.
- Problems in materials availability and import time.
- Variations in materials quality.
- Controlling the quality of the supply chain.
- Delays in payments from the client.
- Lack of skilled workers and a lengthy process of recruitment.
- Poor communication with regulating bodies.
- Clients constantly change designs or requirements.
- Delay in receiving project-related information.

B. Sharing Knowledge in Construction Projects

Throughout all the interviews conducted with project managers, it was obvious that the term shared knowledge in construction projects mainly referred to sharing information about the project between working parties and individuals [67]. Also, knowledge is referred to the skills and experiences an individual possesses. Simply put by a project manager, a carpenter's knowledge is represented in his skill to cut wood and past experiences dealing with equipment used to conduct his job. On the engineers' level, knowledge could be the information existing with an engineer in the form of drawings and interpretations of these drawings. It also includes his awareness of the suitable techniques and methods used for accomplishing his tasks. Other project managers see team knowledge as the collection of information and documentation stored on a central server at the site office's IT room.

C. Factors Affecting Shared Knowledge

Factors that affect the knowledge sharing in a project were synthesized into four main factors. The way these factors are ranked does not suggest their importance.

1) Level of Education and Experience

Interviewees agreed that individuals with high educational qualifications and long experience in the industry tend to share information and expertise with other team members. This factor affects the performance of the task by increasing the share of information related to the task being performed. This is endorsed by the study

presented by [68] which illustrates that the members with high educational degrees and long experience are usually more aware of the fundamentals of techniques and methods underlying the construction process by practice and can provide their colleagues, especially fresh graduate engineers, with advice on the way work should be performed.

2) Protective Individuals

The findings of the study suggest that some team members believe that knowledge gives them an advantage and protect their job, and as long as they hold knowledge they are needed. The findings of [69] are consistent with this statement highlighting that the individuals are discouraged from sharing information as they fear to lose a job. Moreover, it also highlighted that knowledge sharing is not practiced because it requires explicating and codifying of knowledge which results in expense in terms of time and effort. This serves as a challenge to project manager for encouraging those people to share what they know with their colleagues and understand that any information combined with what others know will make the project perform better and continue to exist.

Consequently, this will result in sustaining their jobs. In the case of projects, where there are no much knowledge capture mechanisms, the loss of a knowledge protective person from the team could endanger the progress of that project [70].

3) The Ability of Communication

The construction environment is multi-national and cultural [71]. Communication at the project site can be divided into three levels. First, site office level, where the communicating parties are relatively highly educated individuals, such as project managers, construction managers, senior engineers, commercial team, and quality team. For instance, the study of [72] highlighted that due to their education, they possess sufficient office common language, which is English. Their ability to communicate in face-to-face meetings is good, especially when aided by drawings and other office automation tools. Although individuals come from different nationalities, sharing the English language and industry terminologies is a success factor in the communication process, which is supported by the present study findings.

Second, site level, where the communicating parties are workers who are mostly hired from third-world countries because of their low salaries. According to the responses, it is suggested that workers usually do not have adequate education qualifications or may be illiterate. However, many of them possess excellent skills and field experience. Many come from different parts of Asia and do not speak English and do not have a common language [73]. Their communication on site is not much while performing their jobs, due to the different languages they speak, except for some groups who come from the same region or country. But it cannot be assured if the group's communication is related to the project or not.

Third, supervisory level, where site engineers, supervisors and charge hands are linking the chain of command between the office and site. These people usually know more than one language. Project managers prefer to hire these multi-language mediators to ensure that instructions are delivered in the "site language," as phrased by a project manager, to workers. [74] supports the statement by highlighting that communication in construction projects is high at this level because it represents a main two-direction dissemination point of information. Instructions and information are sent to the site and information and progress feedback is received from the site. Earlier work by [75] also supports the findings stating that the contemporary construction project constitutes a large level of complexity and uncertainty, making it essential for the project managers to play an active role at all levels of communication.

The cause of this problem could be one of the following; either a) engineers at site office failed to understand the requirements for the area when they worked out the detailed drawings, or b) supervisors failed to convey the required job to the workers because of their inability to use the proper language to translate instructions to workers, or c) one of the workers (builder or plumber) did not understand the job they should carry out. This is due to their inability to read drawings correctly and depended on verbal instruction provided by their supervisors. The results of [76] are consistent with the research findings and the illustrated example emphasizing the significance a project manager has for establishing liaison among many agents involved in the construction projects and its associated knowledge sharing.

4) Confidence

The interview results suggest that some engineers do not share the knowledge or information they possess because they are not confident in the accuracy of it or they fear to be exposed. For example, an engineer who has completed the task of laying the foundation of a building is not sure that the calculation he derived is the best or efficient for that type of building. Therefore, the engineer would not discuss it with other engineers because this will either show his low capabilities in performing his work or uncover his mistake to the project manager. The present study findings are in correspondence to the study of [77], which explains that both exposures are unfavourable because it first means that engineer is not capable of doing his work professionally and up to standard, and the second means that he wasted project resources by entailing reworks. According to a project manager, this is demonstrated clearly with engineers from third-world countries. They referred this unconfident status to the blaming culture that they came from and believes that it affects the whole team as it starts to spread among them.

D. ICT Use in Construction Projects

Interviews showed an insignificant and shallow use of ICT in the participating companies, which indicates the existence of ample opportunities to improve through ICT employment. There is almost a consensus among interviewed project managers that the benefits of ICT are limited to facilitating the performance of administrative

and functional tasks. However, one extended that ICT could bring some benefits to the communication process, especially if the project works with distributed locations or other parties that are supervising from overseas. This is supported by the study presented by [78], which demonstrates that the ICT can significantly contribute to the construction projects efficiency, affordability as well as successful implementation. The efficiency is improved as laptops are used within some areas of the site environment, and they are intended to make documentation, specifications, and another job-specific work available in a reasonable format. As one of the project managers stated, "we still prefer to use the old fashion means" referring to the paper as an information medium, he continues, "verbal and written communication is the best (formal communication) in the construction projects."

Similarly, companies' adoption of electronic communication means, such as e-mails, seemed not very successful within the site team; but they are successful for the site team out [79]. Although all visited site offices were provided with at least one internet-enabled computer and are connected somehow to a central server, e-mails or electronic messages are used only to move a small amount of information and give small instructions among sites/agents. All interviewed project managers preferred face-to-face meetings, especially within the site office. Radio communication on large sites is very important to project managers, but not enough allowance is made for it often. Using mobile telephones can be great, but it is not effective in some situations, like being in a steel cage six meters below the ground.

It was obvious and explicitly expressed by some project managers that the decision to use ICT in the project is defined according to an economic perspective by the project manager, it is subject to the needs and priorities. A project manager justified this as that not every engineer needs to have a computer. Site engineers are supposed to be on-site and start writing in their daily diaries. These diaries should be "live," according to his description, which means that it includes every aspect and observation on site. These diaries are then aggregated, possibly by a secretary, in one unified document at the office for reporting purposes. He continues to explain and emphasize that a hot desk is usually available at the site office for engineers who want to check their e-mail or search for the task-related specification from the internet from time to time, but site engineers have to be available at least 7 hours daily on-site. A computer at the hot desk can serve ten engineers through managed time slots, he estimated.

On the other hand, the use of project management applications was evident in all the interviewed companies. That included project portfolio management applications (company-level) and project management applications (project-level). The access and use of these applications are usually limited to certain employees in the company or project. Given the recent advancements in ICT capabilities, users became able to generate, process, and share great amounts of information [80]. Cloud computing itself and its capability of including almost any type of tool could be introduced or utilized to improve the existing situation of ICT use for task accomplishment in general and knowledge sharing in specific in the participating companies.

E. Project Performance

Project performance can be measured by its individual members' performance and/or the overall project performance. Construction companies have developed competent systems for evaluating the performance of its employees, starting with project managers, and ending with site workers. One of the common methods a company use is the annual face-to-face appraisal for each individual in the project. It attempts to assess knowledge of work, timekeeping, sickness, contribution to the team, etc. [81]. The assessment follows the chain of command hierarchy in who assesses who. Bonuses are paid based on the individual assessment and the overall company's project performance.

Project managers also assess individual engineers on a weekly basis by producing a weekly program for each. These programs are generally tailored according to project and construction managers' judgments to suit the capabilities of each engineer [82]. Therefore, an engineer's productivity is determined by the accomplishment of his assigned program on time with required specifications and quality. The contribution of individuals to the team's interaction and knowledge is difficult to measure. Some members are quiet, they do not contribute verbally to their team, and however, they do a good job in performing their assigned tasks, which contribute to the tasks of others [83]. Other members do not share problems with the team and prefer to discuss it with the project manager alone to prevent the propagation of negative feelings to the team. Their contribution is limited to the positive things to say.

Meeting delivery dates are properly managed by a project program, which monitors the progress of tasks and activities according to a timeline chart to ensure meeting all milestones on the rescheduled dates. Sub-programs tailored for engineers also help in this process. The study of [84] provides that the efficient use of budget and resources is usually monitored through weekly reports prepared about costing, resources on-site, wastage of materials, and productivity of man-hours. Construction projects are heavy cash demanding; cash flows should always be monitored during the whole lifetime of the project.

Meeting specifications are controlled by quality checks that are set to ensure that the work is conducted upon standards. None Conformance Reports (NCRs) are used as an instrument to indicate the trend of departures of specifications and standards in different aspects of the project, such as quality, program, financials, etc. In the construction industry, it is heavily used in quality control. Some project managers think that when NCRs are issued, a better quality of work is produced [85]. This is because things were checked and corrected according to the required specifications and standards. It is very helpful to control subcontractor's work. These project managers

believe that the more NCRs are issued, the more confident they will be forming the work carried out.

TABLE II. CORRELATIONS BETWEEN TEAM-RELATED AND TASK-RELATED KNOWLEDGE AND PERFORMANCE

Spearman's rho		General Team-related Knowledge	Team-related Communication Skills	Team-related Attitude	Team-related Dynamism	Team-related Working Environment	General Task-related Knowledge	Days project delayed
		QGA	*QGB*	*QGC*	*QGD*	*QGE*	*QGF*	*DELAY*
QG A	Correlation Coefficient	-	.460	.534*	.754**	.269	.125	.268
	Sig. (2-tailed)		.084	.040	.001	.333	.657	.333
QG B	Correlation Coefficient		-	.827**	.810**	.806**	.579*	.387
	Sig. (2-tailed)			.000	.000	.000	.024	.154
QGC	Correlation Coefficient			-	.757**	.735**	.574*	.313
	Sig. (2-tailed)				.001	.002	.025	.256
QGD	Correlation Coefficient				-	.668**	.458	.544*
	Sig. (2-tailed)					.007	.086	.036
QGE	Correlation Coefficient					-	.811**	.535*
	Sig. (2-tailed)						.000	.040
QGF	Correlation Coefficient						-	.162
	Sig. (2-tailed)							.564
DELAY	Correlation Coefficient							-
	Sig. (2-tailed)							

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

The quantitative data collection part of this research is considered preliminary and used to refine the model of the study. The study used a non-parametric analysis to test the relationship in question. The unit of analysis is a project, so the sample size is not sufficient to use a parametric approach. In addition, data was acquired on a selective basis from different projects. Therefore, it was not believed that the nature of this data would be normally distributed. Spearman's ranking correlation test was thought to be best suited for testing the data. As shown in Table II, Spearman's test results supported the existence of an association between some of the variables of shared knowledge and performance. Team-related dynamism and team-related working environments are associated with the delay in project delivery date (p=0.544, Sig. 0.036 and p=0.535, Sig. 0.040, respectively). The results also indicate an association between team-related shared knowledge and task-related shared knowledge variables, where team-related communication skills, attitude, and working environment showed a significant correlation with general task-related knowledge (p=0.579, Sig. 0.024, p=0.574, Sig. 0.025 and p=0.811, Sig. 0.000, respectively).

Several limitations have been reported based on the findings of the study. Firstly, the study was unable to collect data from some projects. Secondly, the experienced project managers suggested not to use the data as a measure since they do not represent performance issues. Thirdly, the data was not comparable between projects. Lastly, some companies refused to disclose their profit margins.

6. CONCLUSION

Shared knowledge is viewed by project managers from two aspects. The first aspect is information availability. They believe that the explicit information that appeared in various types of documents is shared knowledge when it is centrally available for access by all team members. The second aspect is the individual skills. They assume that the sharing process depends on the skills an individual possesses, such as language, communication, and technical skills. Knowledge sharing is affected by some factors such as the level of education and experience, existing of protective individuals, the ability of individuals to communicate with each other, and the confidence of possessed knowledge and skills. The main contribution of ICT in the construction process, currently, is to support administrative tasks. The nature of the tasks performed requires immediate response or discussion, which cannot be facilitated by the ordinary communication infrastructure used. ICT contribution to construction project management needs to be studied further to understand its mediating effect on the relationship between shared knowledge and performance. The model proposed in this paper can be used to study the causal effect empirically using a larger sample size and relationship direction analysis techniques.

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