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Abstract

There is a concern about how best to plan and control projects and how to determine what the optimised strategies should be depending on the project type, size and culture. Existing scheduling methods do not provide accurate progress and forecast information and fail to integrate different productivity rates. Therefore, various techniques have been developed to improve project outcomes. This paper investigates the implementation of a collaborative planning method to improve processes within the construction industry. Collaborative planning aims to achieve lean goals by trying to make planning a collaborative effort and by improving the reliability and commitment of the team. Collaborative planning is known to be the most developed practical use of Lean construction. It focuses on minimising the negative impacts of variability and uncertainties, making projects more predictable, with more reliable work plans and better forecasting. This was quantitative research through a survey which was sent to the project team involved in the case study project, followed by an interview-style survey with key professionals from the project. The case study for this paper is a major rail project in the Gulf Cooperation Council (GCC) area.

Key Words: Construction, Planning, Time, Cost, Collaboration, Lean

Introduction

Planning and scheduling in construction have been an active subject of research since the 1950s and in that time many techniques and methods have emerged. The industry has adopted the critical path method (CPM) as an influential pattern for practical scheduling (Monden, 1998; Feld, 2001). Yet, in the research community, there has been resistance to accept this as the only method. In construction, where the CPM dominates in practice, it is powerful to use these divisions to identify alternative strategies and to justify their use for particular aims, or even make the case that alternatives are superior for planning and control of construction projects.

This paper aims to explore the extent to which the implementation of collaborative planning on construction projects can improve productivity. The research method will introduce the case study project, along with descriptions of the ways that collaborative planning was applied. The benefits of this method in terms of improving the construction management practice will also be explored, along with both the critical success factors and barriers for implementation.

The Problem

Construction projects are high risk and often lead to disputes and claims as work progresses, which subsequently affects progress. In construction, it is necessary to identify potential problems in advance, to avoid and overcome possible impacts on cost or project time. Productivity problems often lead to time and cost overruns on construction projects; according to (Gray & Flanagan, 1989), the average construction worker is only productive for 40% of the time, the remaining 60% is spent moving from one task to another or waiting for materials and/or instruction. Conducting descriptive studies is not enough, we need practical solutions to problems in construction management, for example, novel management techniques like Lean construction could be developed and practically implemented (Conversely, Alsehaimi et al., 2009).

The Lean construction community supports that research should be centred on the development of solutions that are explicitly aimed at solving practical problems (Koskela, 2008). Therefore, this case study is focused on improving construction workflow and project management through the use of planning techniques and tools, and through the Lean construction technique of collaborative planning.

Lean Construction

Lean construction is a philosophy based on the concepts of lean manufacturing. It is about managing and improving construction processes to fruitfully deliver what customers need. Lean construction can be pursued through various approaches. One of the first companies to deviate from traditional mass production was Toyota, which introduced numerous manufacturing philosophises to increase their production line. The production philosophises that were proposed and implemented by Toyota are known as the Toyota Production System, which formed the basis of Lean (see Figures 1.1) (Howell, 1999).

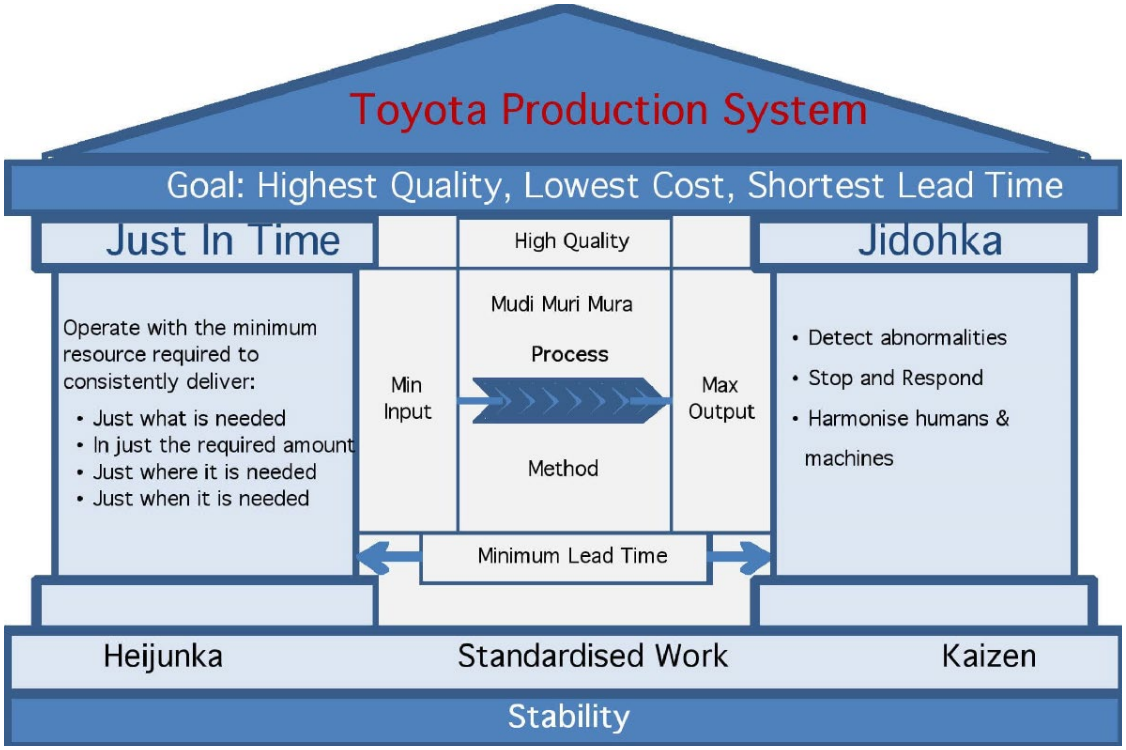


Figure 1.1. The Five Principles of Lean to reach the goal of the Toyota Production System.

The model is known as 'Just in Time' (JIT), promoted by Taichi Ohno, who incorporated the Ford production techniques and other methods into their manufacturing and production line of cars (TOYOTA, 2015). The founder of the Toyota Corporation, Sakichi Toyoda, studied Ford's operations for three months, where he observed the possibilities for improvements in his production plant. In collaboration with his team, they were able to recognise the waste in Ford's operations, even though the procedures were acknowledged as the world's most efficient (Lincoln H. Forbes, 2011). According to the Lean Construction Institute (LCI), the Lean construction approach is a new way to manage construction projects. The method has been defined as 'the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream, and pursuing perfection in the execution of constructed projects' (Lincoln H. Forbes, 2011).

Flow variability greatly influences Lean construction practices because the late completion of one trade can affect the overall completion time of projects. 'The last planner' is a technique that supports the realisation of plans on time (Ballard, 2000). Last planners are people accountable for the completion of individual assignments at an operational level.

The Use of Collaborative Planning in Construction Projects

Collaborative planning aims to increase productivity by only allowing the planning of assignments which are ready to enter weekly work plans. It thus concentrates on ensuring work is ready by having materials and resources available, site works accessible, all approvals attended, assignments well defined and produced by a person or a group of people called the 'last planner/s'. In the Last

Planner System (LPS), master schedules are limited to phased milestones, special milestones, and long lead time items. These phased schedules are planned by teams who work using pull techniques. Once the phase schedule is ready, the look-ahead will be extracted from it, to assign next week tasks at the end of the previous week. Percentage of the Plan Complete (PPC) is calculated, and any failed assignments are recovered, and preventative action applied to avoid its re-occurrence in the future. Figure 1.2 illustrates the stages in LPS.

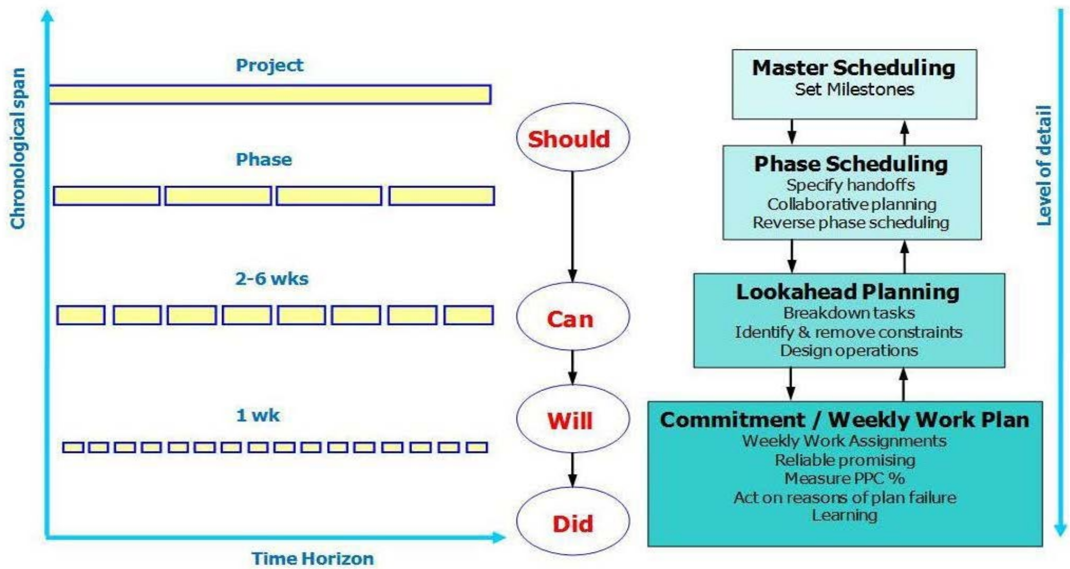


Figure 1.2. Planning stages/levels in the Last Planner System (adapted from Ballard, 2000).

The last planner process starts with the Reverse Phase Schedule (RPS), i.e. a detailed work plan specifying hand-off between trades for each phase (Ballard and Howell, 2003). Based on the RPS, a 'look-ahead' schedule provides the activities to be completed during the coming weeks and the backlog of ready work. Each planner prepares weekly work plans to control workflow. If assignments are not completed on time, planners must determine the root cause of the variance (i.e. the difference between Forecast Vs Actual) and develop an action plan to prevent the future repetition of the problem. It is the responsibility of the management team to adapt this system, as required for the project. The tools selected will depend on the project size, the type of collaboration with the participants, the contractual requirements, previous experiences, and human factors.

The First Run Studies (FRS) is an integral part of the LPS and is based around the Plan-Do-Check-Act cycle (PDCA) (O. Salem, 2005). According to O. Salem (2005), the process is shown using video files, photos, or graphics. Furthermore, it is essential to carefully examine the first run of selected operations, exploring innovative ideas and alternative proposals (Glenn Ballard, 1994). As mentioned before, the FRS suggest the use of PDCA cycle (Figure 1.3), to develop the study which consists of four phases. The 'Plan' phase refers to the process that needs to be selected to study: Assemble the right team of people, identify the quality, process, and productivity to brainstorm ideas and eliminate unnecessary steps. 'Do' is for testing and deciding alternative solutions on the first run, while 'Check' is to describe and measure the tested process and what happens. Lastly, ‘Act’ “refers to reconvene the team, and communicate the improved method and performance as the standard to meet”. (O. Salem, 2005, p. 4)

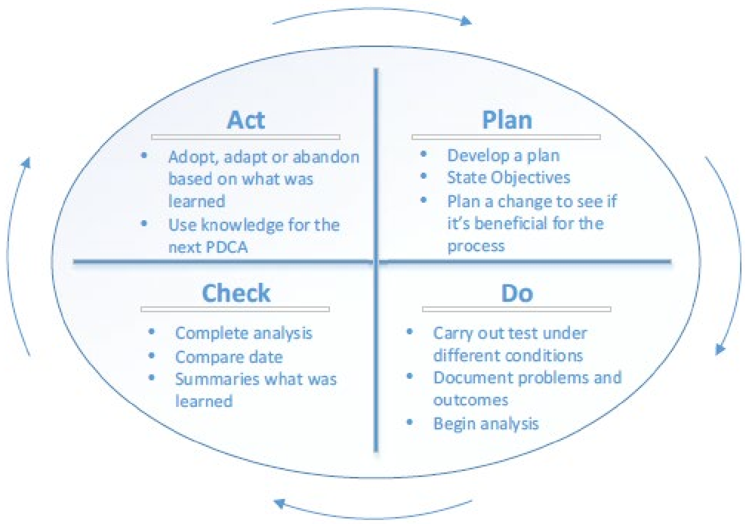


Figure 1.3: PDCA Cycle

Literature Review and Issue Identification

For many years, the construction industry had 50% of the activities scheduled not finished on time (Ballard, 2000). This was mainly caused by the traditional push philosophy of construction, where the activities are included in the schedule before ensuring that it can be performed, leading to improper decisions. Thus, there arose a need for a robust system to enable the stakeholders involved to collaboratively predict the ongoings and commit themselves to the tasks they agreed to perform. The difficulty of planning and control in construction projects is because it involves different parties, at various locations and time, during the project lifecycle and these elements need to interact with each other appropriately for successful project completion (Ballard, 2000). LPS is more than a structured system, it is a philosophical approach of the necessary mindset that the project team need to have; it involves collaboration, commitment to the project, and team coordination and interfaces (Mossman, 2013).

The traditional planning method often does not differentiate between the activities that ‘should’ happen with those that ‘can’ happen (Figure 1.4). Whereas in the LPS follows a workflow defined by Should-Can-Will-Did (Figure 1.5). The Make-Ready process is the phase where the activities that ‘Should’ be done are ensured that they ‘Can’ be done and all the possible constraints are removed. Later in the process, in the Weekly Work Plan (WWP), the different parties involved in the project agree on when they ‘Will’ do them. After the planned activities are executed, the parties in charge consider what they actually “Did”. The PPC is calculated and the delays that may appear are analysed for future avoidance (Jang, 2008).

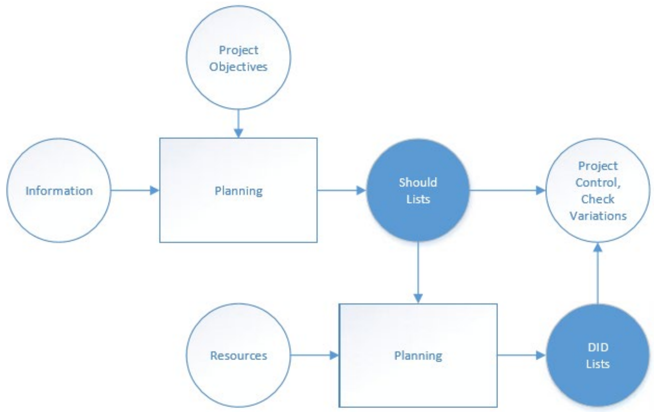


Figure 1.4: Traditional Construction Sequencing

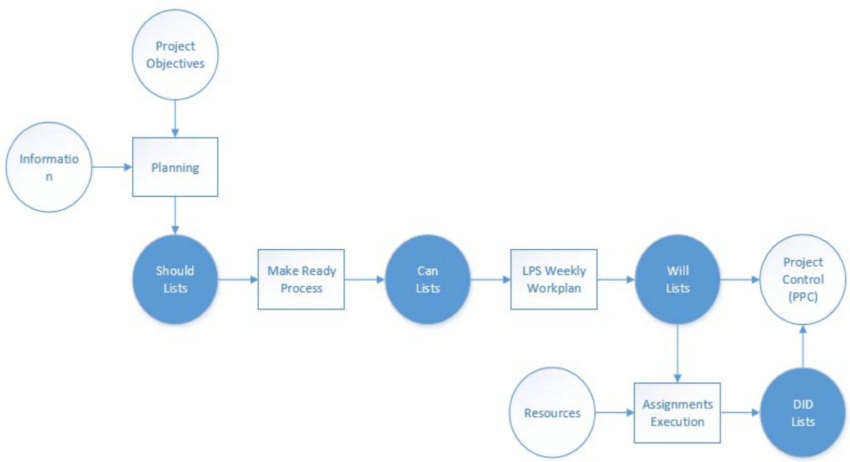


Figure 1.5: LPS Construction Sequencing

After comparing the diagrams of the traditional method versus LPS (Figure 1.4 and Figure 1.5), it can be concluded that the traditional construction method has no control barriers between the activities that should be performed and the activities that are actually done, to check whether they can be done or not. This 'check-point' from LPS to ensure that the scheduled activities can be done, increases the reliability of the plan and reduces variances, which is one of the main benefits of LPS (Mossman, 2013).

Methodology

This paper investigates best practice for implementing LPS in construction. The research aims to provide essential information about LPS and its use in construction projects in Gulf Cooperation Council (GCC) countries. The data was collected through a questionnaire survey, followed by interviews. A questionnaire was preferred as the most effective and suitable data-collection technique for the study. The questionnaire was a self-administered tool with web-designed questions. However, for this approach, the questionnaire response rate is lower compared to the interviews. Data was collected for the literature review from books, journals, and articles. A survey was given to the project team from professions involved in Qatar's largest metro project.

Collaborative Planning Questionnaire

The questionnaire was divided into four sections. The first section was to establish the profile of the participants and that of their organisations. The next section reviewed the benefits recorded in the implementation of collaborative planning while the last sections dealt with the critical barriers and success factors of implementation.

Survey and Questionnaire Revision

A face-to-face discussion was conducted with ten construction professionals. This procedure improved the validity of the survey. Questionnaires were sent by e-mail to the project teams. Twenty replies were received. Mindful of a relatively low response rate, it was decided to supplement the data collection process with qualitative interviews with construction professionals.

Questionnaire Distribution

The target groups in this study were professionals involved in the project. With a volume of 550 professionals (Project controls, planning, estimators, construction, Engineers and Managers). The sample size can be calculated with the following equation for a 95% confidence level (AlShahri et al, 2001) and (Moore et al, 2008):

$$n = \frac{n'}{\left(1+\frac{n'}{N}\right)} \qquad (1)$$

Where, n= total number of population, N = Sample size from a finite population, n' = sample size from an infinite population= S2/V, S2 = the variance of the population elements and, V = a standard error of the sampling population. (Usually, S= 0.5, and V = 0.06).n'= S2 / V2 = (0.5)2 + (0.06)2 = 69.44, for N=547, n = 69.44 / [1 + (69.44 / 547)] = 62. To obtain 95% of confidence level, it was calculated to send the questionnaire to minimum of 62 participants.

Data Collected from the Web Survey

To successfully achieve the objective of the study, one of the most important phases is the collection of accurate data. Data collection is a procedure for collecting data records for a certain sample or population of observations (Bohrnstedt and Knoke, 1994).

Analytical Method Used

To facilitate the study, after the literature review and the focus interviews, a plan was formulated for collecting field information and creating an evaluation process and numerical values. It was necessary to provide straightforward communication to participants to ensure a clear understanding of all the applicable definitions, procedures, and guidelines that were used in collecting data. Because the data-collection process included individuals, two different ways were used to analyse the survey results.

Dispersion

Central tendency tells us important information, but it does not show everything we want to know about average values. There are two common measures of dispersion, the range, and the standard deviation. The range is simply the highest value minus the lowest value. The Standard Deviation is a more accurate and detailed estimate of dispersion because an outlier can greatly exaggerate the range. The standard deviation goes further than Range and shows how each value in a dataset varies from the mean. The Standard Deviation shows the relation that the set of scores has to the mean of the sample.

Sample standard deviation formula.

$$S = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n - 1}} \quad (2)$$

Population standard deviation formula.

$$\sigma = \sqrt{\frac{\Sigma (x - \mu)^2}{N}} \quad (3)$$

where:

- X is each score,
- $\bar{X}$ is the mean (or average),
- N is the number of values in a population
- n is the number of values/scores,
- Σ means we sum across the values.

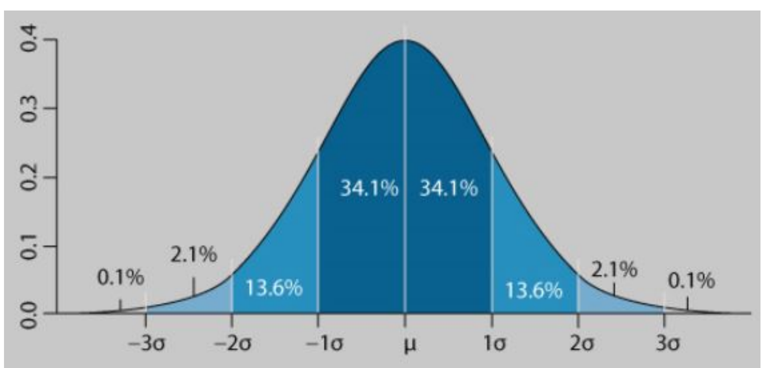
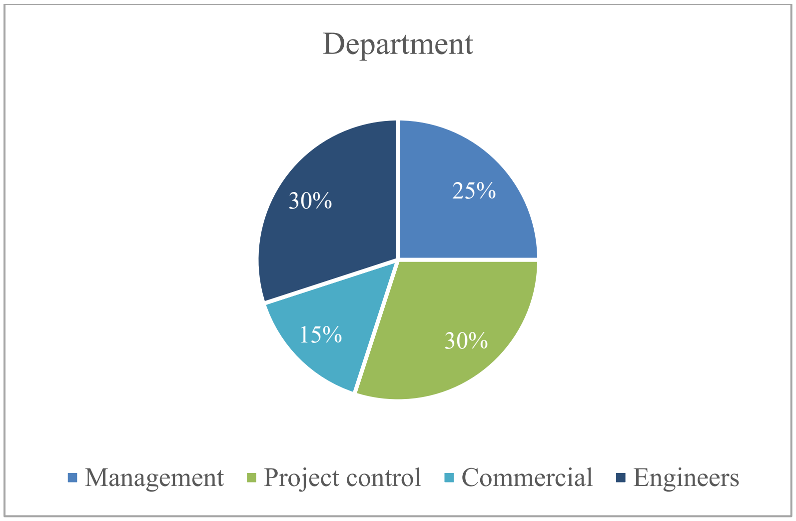


Figure 1.6: research methodology

Results

Participants details



The local survey was shared among the project team involved in the Doha metro project. The completed responses, representing participants from project management (5), project controls (6), commercial (3) and Engineering teams (6).

Table 1: Over result for implementing collaborative planning in construction project

Please indicate to what extent you agree or disagree with the following statements (0=Strongly disagree, 1=Disagree, 2=Neither agree/disagree, 3=Agree, 4=Strongly agree)

Results	*Mean*	*Median*	*Mode*	*Percentage*	*Range*	*Standard Deviation*	*Rank*
Collaborative planning was very effective within this project	3	3	3	75	2	0.725	2
The results achieved from implementation on previous projects are satisfactory	2.7	3	3	67.5	3	0.733	3
The weekly work plans were very useful	3.1	3	4	77.5	3	0.912	1
It was difficult carrying out the implementation	2.55	3	3	63.75	3	0.999	4

The findings from the survey suggest that the implementation of collaborative planning in construction projects is useful.

Table 2: Barriers during collaborative planning implementation in construction projects in GCC countries

How often did your Project Management team incur the following barriers during implementation? (0=Never; 1=Rarely, 2=Seldom, 3=Frequent, 4=Very Frequent)?

Results	Mean	Median	Mode	Percentage	Range	Standard Deviation	Rank
There was inadequate supervision	2.1	2	3	52.5	4	1.071	4
There were many fluctuations and variations	2.65	3	3	66.25	4	1.040	1
There was subcontractors lack of involvement	2.55	3	3	63.75	3	1.050	3
There was resistance to change	2.65	3	3	66.25	4	1.040	1
There were many negative cultural issues	1.65	1.5	1	41.25	4	1.137	5
There were lengthy approval procedures by the client	2.55	3	3	63.75	3	1.146	2

The findings from the survey suggest that the major barrier to be considered during collaborative planning implementation is the fluctuations and variations.

Table 3: Critical success factors to the implementation of collaborative planning in GCC.

Please indicate to what extent you agree or disagree with the following are critical success factors for the implementation of collaborative planning (0=Strongly disagree, 1=Disagree, 2=Neither agree/disagree, 3=Agree, 4=Strongly agree)

Results	Mean	Median	Mode	Percentage	Range	Standard Deviation	Rank
Training Site supervisor, foreman, etc	3.2	3	3	80	3	0.834	1
Involvement of all project stakeholders	2.9	3	3	72.5	3	0.852	6
Motivating people to make changes	2.95	3	3	73.75	3	0.826	5
Having the appropriate Human Capital	3.15	3	3	78.75	2	0.671	4
Top management support	3.5	3.5	4	87.5	1	0.513	2
Management resistance to change	2.35	3	3	58.75	4	1.182	8
Close relations with suppliers & Subcontractors	2.9	3	3	72.5	2	0.641	7
Skilled BIM engineers and provide training to project staff	3.2	3	3	80	2	0.696	3

The findings from the survey suggest that training, management support, skilled BIM engineers and having the appropriate human capital, are the major success factors being considered to collaborative planning implementation.

Table 4: Benefits of the implementation in construction projects in GCC

Please indicate to what extent you agree or disagree with the following benefits have been gained from implementing collaborative planning; (0=Strongly disagree, 1=Disagree, 2=Neither agree/disagree, 3=Agree, 4=Strongly agree)

Results	*Mean*	*Median*	*Mode*	*Percentage*	*Range*	*Standard Deviation*	*Rank*
Identifying & addressing potential problems before they become obstacles in the project	3.35	3	3	83.75	3	0.745	1
Reducing the incidence of bad news	3.05	3	3	76.25	2	0.686	8
Developing supervisory skills and reducing the load on management	3.15	3	3	78.75	3	0.813	3
Creating a more predictable reliable production programme	2.9	3	3	72.5	3	0.788	9
Delivering projects at reduced cost	3.05	3	3	76.25	3	0.826	6
Improving construction logistics on projects	3.05	3	3	76.25	2	0.605	7
Improving predictions of labour required	3.1	3	3	77.5	2	0.553	5
Reduces the risk of catastrophic loss	3.15	3	3	78.75	2	0.587	4
Completes projects on schedule	3.35	3	3	83.75	2	0.587	2

The findings from the survey suggest that delivering projects on schedule, avoiding delays and decrease risks, are the major benefit of the collaborative planning implementation.

Conclusion

The findings from the survey on the hurdles for collaborative planning implementation support the literature reviews: cultural issues, lengthy approvals, resistance to change, supervision and quality control, subcontractor's involvement, fluctuations, and variations. Accordingly, a framework is developed to overcome the hurdles identified. This framework included the need to; identify the purpose, identify the stakeholder's impact, obtain sponsorship, build cross-functional teams, create measurement indices, create the right working climate and provide for training on lean techniques and collaborative planning. This framework was further validated by industry practitioners within the field of the study and positive feedback was obtained from focus group discussions. Considering the survey results above, it is concluded that WWP and monitoring tools for construction operations are beneficial for resource planning and aid in producing effective construction schedules. The findings from the survey revealed that implementing collaborative planning on the project created predictable and reliable project plans, identified and removed constraints before they became obstacles, improved logistics at the site, and completed the projects with project duration and cost.

Recommendations

The proposed framework is not a 'pick and choose' toolbox or a rigid step-by-step framework, rather it is a guideline as to what should be in place to promote the successful and effective implementation of collaborative planning. Implementing collaborative planning, like LPS is usually a lengthy process, but it promises to improve planning, control and coordination. Hence, it requires a lot of commitment and patience from practitioners seeking to implement it for the first time, knowing that planning and control are dynamic and iterative processes.

Future Research

Further research should focus on the holistic barriers of implementing collaborative planning and development of a universal implementation framework that can fit into any construction environment. In the same vein, further work should be undertaken in applying the same research in other developing countries. Similarly, additional research should be made in the adoption of other Lean construction tools and techniques within the UK. The framework developed in this research facilitates the implementation of the Last Planner System in construction projects.

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