The relationship between the last planner® system and collaborative planning practice in UK construction

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Abstract

Purpose – The purpose of this study is to identify how the newly emerging UK practice of "Collaborative Planning" (CP) for construction project delivery aligns with the advocated principles of the Last Planner System (LPS) of production planning and control.

Design/methodology/approach – A mixed, qualitative, exploratory approach was adopted for the study. This entailed qualitative data through three techniques, namely: semi-structured interviews, document analysis, and structured observation. Thirty in-depth-interviews were conducted over a 12 month period with lean construction consultants, clients, main contractors, and subcontractors drawn from the building, highways and infrastructure and rail sector. Fifteen projects were visited where practices were observed.

Findings – The study reveals that the current practice of CP in the UK partially aligns with the LPS principles. Where practitioners have heard of the LPS they believe it to be the same practice as CP.

Limitation: This study is limited to 30 interviews, observation of 15 projects and document analysis. The aim of the study is not to generalise the findings, however, since the study examined top construction companies and practitioners in the UK and the findings were consistent across the sample, some conclusions could be made. The study is also limited to examining the construction phase only, future studies should incorporate the design phase.

Practical Implication- A clear identification of the elements of current practice compared to the components of the LPS provides a contribution to the future practice of project production planning and management in the construction industry.

Social implication – The study highlights a continuing resistance to collaboration within the industry. This resistance is subtly embedded within implemented practices even though they are based on collaborative working for their success.

Originality and Value – This is among the first studies in the UK that comprehensively examines and reports the application of Last Planner System/Collaborative Planning practice in construction across the major construction sectors. Future studies could build on the findings from this work to develop an approach/methodology to improve the current practice.

Paper type: Research paper

1.0 Introduction

The call for improvement in the UK construction industry and the dissatisfaction from stakeholders has been a subject of debate over many years with the first report to review the performance of the UK construction industry commissioned back in 1929 (Cain, 2004). The Egan report, generally called Rethinking

[1]Trademark registered in the USA by the Lean Construction Institute (U.S. Patent No. 3,020,113, 2005) , in the EU by Köster GmbH (EU Patent No. 004516324, 2006).

Construction, challenged the lack of collaboration in planning, designing, and executing work on site, and recommended the adoption of lean production principles to enhance the image and efficiency of the industry (Egan, 1998). As a follow up action to Egan's challenge, the Construction Lean Improvement Programme (CLIP) was inaugurated to drive lean in the industry (BRE, 2006).

However, the prevailing approach to planning does not support lean production principles (Ballard and Howell, 1997). According to Ballard and Howell (1998), Ballard and Howell (1994) the current model used in planning and managing the execution of work in the construction industry is 'project' control rather than 'production' control which contributes to the non-achievement of task as planned. The problem with this is that planned tasks are not achieved as planned due to the lack of collaboration and involvement of stakeholders in the planning process. These stakeholders include the client, designers, subcontractors, main contractors, and site operatives among others. The impact of this is evident in the construction industry globally (Nasir *et al.*, 2013; Cain, 2004), including the UK. For instance, it has been reported that about 50% of construction projects suffer both cost and time overrun in the UK (Crotty, 2012).

However, the Last Planner® System (a lean production approach) invented in the 1990's has been identified as a production planning and control technique for construction, that engenders collaboration among the project stakeholders (Ballard, 2000). Papke and Dove, (2013) described the LPS as a production planning and management (PPM) method for construction. In this study, PPM is used to describe the application of production planning and control principles in construction based on the LPS. Over the years, planning and control has been understood to be among the core management functions including construction management (Burke, 2013). However, while planning and control are separated in traditional construction project management, this is seen as an integrated process in the LPS of construction management (Ballard and Howell, 2004; Ballard, 1997). This makes the planned construction programme more predictable and reliable, thus leading to reduction in lead time in the construction phase (Alsehaimi *et al*., 2014; Ballard *et al.,* 2009; Alarcón *et al*., 2005; Ballard and Howell, 1997).

In practice, the LPS stabilises the production (construction) process on a project by identifying relationships, matching it with plans and balancing resources (Mossman, 2014; Ballard and Howell, 2003). The LPS establishes relationships between people, tasks, locations, materials, drawings, time, information, and resources, so as to develop a common understanding of the project goals among stakeholders (Pasquire, 2012; Koskela, 2000). This supports smooth flow of work, collaboration and commitment from all project participants, thus delivering value for all the stakeholders on the project (Koskela and Ballard, 2006).

The implementation of the LPS has gained prominence in the construction industry and its influence on the production system seems to be rapid and significant (LCI, 2015; Daniel *et al.,* 2015). However, it has been observed internationally that the LPS has been implemented under different names (Koch *et al.,* 2015; Kalsaas *et al.,* 2014). In Norway, construction practitioners call the

LPS names such as "Collaborative Planning", and "Collaborative Project Execution" among others (Kalsaas *et al.,* 2014).

In the UK, the term "Collaborative Planning" (Koch et al., 2015; BRE, 2006) is used to describe an approach to delivering construction projects from a PPM perspective. The term "Last Planner" and "Last Planner System" are also used (Koch *et al.,* 2015; Johansen, 2003). It has been speculated that the application of the LPS is stalled at collaborative planning/collaborative programming and it is viewed only as a scheduling tool in the UK (Sarhan and Fox, 2013; Mossman, 2009). In order to understand the differences and similarities in these practices in the UK, a review was undertaken through literature, observed practice, and interview. The research question therefore is: The research question therefore is: How does the current understanding and application of "Collaborative Planning" (CP) for delivering construction projects in the UK from a Production Planning and Management perspective align with the advocated principles of the LPS?

Few studies have explored the practice of Last Planner System/Collaborative Planning (LPS/CP) across the major sectors of the UK construction industry. Previous studies on LPS/CP practice in the UK construction industry seem to only report pilot studies and are organisation specific (Koch *et al.,* 2015; Drysdale, 2013; BRE, 2006; Johansen and Porter, 2003). Most of these studies are too narrow and unable to reflect the current LPS/CP across the major sectors of the UK construction industry. Also, the focus of those studies is certainly not to examine how the current CP practice aligns with the advocated LPS principles. However, the study reported here examines the current LPS/CP practice across the major construction sectors (Building, Highways & infrastructure and Rail) in the UK, thus offering a more comprehensive data on the current practice and on how it aligns with the LPS principles. Future studies could build on the robust findings from this work to develop an approach/methodology to improve the current practice.

2.0 Literature review

2.1 Last Planner System principles

The LPS developed by Ballard and Howell focuses on reducing workflow uncertainty identified as a missing component in the traditional project management kit (Ballard and Howell, 2003). The influence of the LPS in managing the production process in construction has been posteriorly rationalised through theories relating to decision-making and uncertainty in the production process (Ballard *et al.,* 2009). These include

- Transformation, Flow, Value theory (Koskela and Ballard, 2006)
- The Language/action perspective (Macomber and Howell, 2003)
- Hayek's, (1945) comment about the way knowledge needed for planning is dispersed among individuals.

The underlying theories of the LPS revolve around planning, execution, and control. According to Ballard and Howell (2003), LPS focuses on planning and production control as opposed to directing and adjusting resources in the traditional project management approach (thermostat model). There are 5 key principles in the LPS (Ballard *et al.,* 2009), and these are;

- ensure tasks are planned in increasing detail the closer the task execution approaches.
- ensure tasks are planned with those who are to execute them
- identify constraints on the planned task to be removed by the team beforehand
- ensure promises made are secure and reliable and
- continuously learn from failures that occur when executing tasks to prevent future reoccurrence.

Ballard (2000, p. G-14) stated that *"the Last Planner(s) is the person or group that make assignments to direct workers"*. The LPS process is based on six components which support collaboration through social conversations (Ballard, 2000; Macomber and Howell, 2003). Social conversation here refers to the face to face discussion that occurs among the Last Planners in the planning process (Gonzalez *et al.,* 2015; Macomber and Howell, 2003). This is opposed to the technical approach used in traditional planning (Ballard and Howell, 1997) which depends upon planning specialists and results in schedules and plans being pushed (imposed) onto the project team.

2.2 The components of the LPS

The LPS integrated components include; (1) milestone planning (2) collaborative programming or phases planning (3) look-ahead planning (4) make-ready process (5) weekly work planning (6) measurement and learning (Ballard, 2000; Ballard and Howell, 2003). These components will be discussed briefly.

- *The master plan or milestone planning*

  The master plan or milestone planning captures the entire task to be executed throughout the project and at the same time shows the length of time required for each activity to be completed. It identifies the project milestones and initiates the means for achieving them (Ballard, *et al.,* 1997). It forms the basis for the development of the collaborative programme or phase planning.

- *Collaborative programming or phase planning*

  Collaborative programming is a process used in developing a reliable construction programme from the master or contract programme by direct involvement of the subcontractors, contractors, suppliers, designers and other stakeholders on the project including the client. It is worth noting that this process is commonly called collaborative planning or programming by practitioners in the UK, while phase scheduling is the common name used for it in Lean Construction Institute literature (Ballard, 2000; Ballard and Howell, 2003).

- *Look-ahead planning*

  The look-ahead planning is a medium term plan for project activities and is developed from the collaborative programme considering the work to the next level of detail. Usually, tasks that will occur within four to six weeks in the look-ahead window are screened for constraints in all eight flows. These include the seven process flows such as information, permissions, resources, space etc. (Bertelsen *et al.,* 2007) and the plus

one soft flow 'common understanding' (Pasquire, 2012). However, in the traditional way of managing projects, the look-ahead plan (master programme) only provides advance notice of the start date of an activity and does not consider the complex network of flows, their sequence, matching work flow with capacity, or maintaining a backlog of workable activities (Ballard *et al.,* 2009).

- *Make-ready process*
  The make-ready process is used to eradicate the constraints or blockers to planned activities identified in the look-ahead programme before they are passed into production on site through a constraints analysis process. Now, work needs to be considered in a greater detail as the make-ready process focuses on matching the available resources for work with the present realities on the construction site, so as to ensure production can proceed at an optimum level (Ballard, 2000; Ballard and Howell, 1998). The purpose of the make-ready process is to prepare for flow – all seven resource flows (Bertelsen *et al.,*2007) plus one soft flow (Pasquire 2012) need to be considered to enable the constraints to be removed and the resources and capacity balanced to enable successful production.
- *Weekly Work Planning*
  Weekly Work Plan (WWP) is done to review the task planned in the previous week in order to plan for the week ahead collaboratively with the team. At this point, only tasks that meet the four criteria of production are entered onto the WWP. These criteria require that work must be 1. well defined (detailed task breakdown), 2. sound (can be done), 3. sequenced (interdependencies assessed) and 4. properly sized (load matches capacity). Tasks meeting the four criteria but not entered onto the WWP are held in readiness as a "workable backlog" or Plan B tasks. The workable backlog enables the workforce to drop onto these tasks if for any reason they are unable to complete work on the WWP (Ballard, 2000). '*Daily huddle'* meetings are used to monitor how activities planned for the week are performing each day (Ballard *et al*., 2009; Salem *et al*., 2006). Its focus is to guide the planned production from deviation and to re-plan when such is envisaged. This was not an initial component of the LPS (Daniel *et al.,* 2015; Ballard *et al.,* 2009).This practice is commonly known as '*daily stand up'* meeting in the UK.
- *Measurement and learning*
  The key metrics measured in the LPS implementation are; the Percentage Plan Complete (PPC), the Reason for Non-Completion (RNC) and a developing Reliability Index using metrics from Tasks Made Ready (TMR) and Tasks Anticipated (TA) (Ballard, 1997; Hamzeh *et al.,* 2015). In practice, PPC measurement, and recording of RNC not only encourage learning but also provide a clear indication of productivity (Liu and Ballard, 2008; Ballard, 2000). Evaluation and learning within a lean construction system is tightly coupled to action (Koskela *et al*., 2010; Lichtig, 2005; Ballard, 2000). In this way, the PPM becomes agile and responsive to uncertainty and risk in problem solving generating action in the moment – it is not enough to leave evaluation and learning until project closure.

2.3 Origin of collaborative planning

The term "collaborative planning" (CP) is now used in various fields, but the origin of this concept remains debatable. In order to understand the use of the term "collaborative planning" a search was done using Google Ngram[2] which revealed that publications using that phrase began to increase from the 1960's as shown in Figure 1 (Google Ngram, 2015). The y-axis in Figure 1 shows the relative frequency, in % of the occurrence of the phrase 'collaborative planning' in Google books, while the x-axis shows the compendium of published information on collaborative planning available in Google books across the years searched.

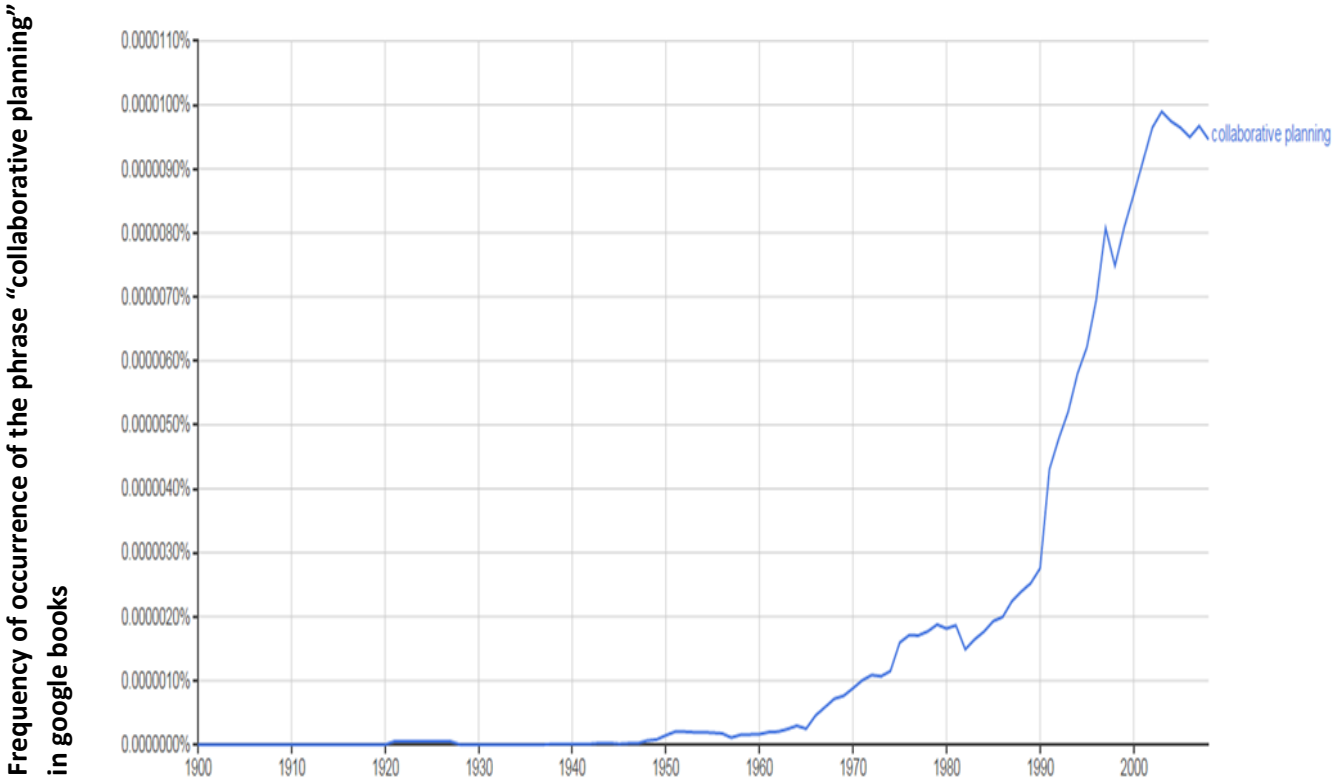

Figure 1: Frequency of occurrence of the phrase "collaborative planning" in google books

Source: Google Ngram

Additional analysis of the results reveals that the earliest use of the term CP was associated with urban planning and educational planning (Perloff, 1961; Davidoff, 1965; Florida State University, 1975). However, its usage has since increased significantly, which supports the claim that the term has entered into more common language in diverse fields such as the military, manufacturing, software development and construction (Riley *et al.,* 2006; Highsmith and Cockburn,

[2] Google Ngram Viewer is an online viewer, initially based on Google Books, that graphically presents the frequencies of any word or short phrase using yearly count of n-grams found in the sources printed over the selected years in American English, British English among other languages (Google Books Ngram Viewer, 2015).

2001; Mokhtar *et al.,* 2000). Gunton *et al.,* (2003) observes that CP has its roots in UP and was developed as an alternative to the traditional rational comprehensive model (RCM) approach to planning in North America after the World War II. The RCM school of thought argued that, since planning was a technical scientific discipline, planning decisions could only be performed by experts (Wondolleck and Steven, 2000). It could be argued that the current traditional approach, used in the design, planning and execution of work in the construction industry can be likened to the rational comprehensive model (RCM) used in urban planning (Daniel *et al.,* 2014b; Gunton, *et al.,* 2003)". The RCM could also be said to describe the 'command and control' approach used in construction management. However, in urban planning this approach was challenged in the 1960s and the concept of CP was introduced (Gunton *et al.,* 2003). Figure 1 further confirms this assertion, as it reveals that the use of CP became prominent in the literature after the 1960s.

CP focuses on creating participative platforms for stakeholders *before* decisions are made. The attempt to create collective decision sharing points advocated in CP is now seen in various practices such as co-location, co-design, in the medical sciences, software development and engineering design among others (Mojir and Pilemalm, 2014; Boudreau *et al.,* 2012). This suggests that CP is not a specific approach for managing production in the construction industry. Rather, it is a more generic term used in common language to describe shared decision making to the benefit of stakeholders. Consequently, the characterisation of the actions that occur in phase planning in the LPS can be said to entail CP in the common sense of the term.

2.4 Global perception on LPS and CP in construction

While the LPS is widening its effects on construction process improvement (Alsehaimi *et al.,* 2014; Alarcon and Calderon, 2003), it has also been branded under other names by industry users to suit different goals in various parts of the world. For instance, in Norway Kalsaas *et al.,* (2014) observed that companies tend to use such terms as "*collaborative planning"* in (Veidekke and Kruse Smith), and "*Collaborative Project execution"* (Nymo). Similarly, Zimina and Pasquire, (2012) observed that in the UK, the principal elements of the LPS are implemented as CP.

However, it can be argued that this different translation for the LPS has not fully supported the development of an effective production system as intended in the LPS. In Norway, Kalsaas *et al.,* (2014) observed these different versions or translations of the LPS have not worked in supporting the full implementation of LPS on the project as only a few elements of the LPS are implemented in these approaches or translations.

3.0 Research methodology

A mixed qualitative research approach was adopted for the study. This entailed qualitative data through three techniques namely: exploratory semi-structured interviews, documents analysis and structured observation. Exploratory interviews were used since the study aimed to examine the current understanding and application of LPS in the UK construction industry by

exploring the social settings (the UK construction industry sector) and the individuals inhabiting it (the UK construction practitioners). Creswell, (2009) observed that exploratory interviews are appropriate when a study seeks to know the meaning people ascribe to an event and not the meaning from literature alone; which aligns with the aim of this study. It has been observed that no research method "can provide the detailed understanding that comes from directly observing people and listening to what they have to say at the scene" (Taylor and Bogdan 1984, p. 79). Therefore, the interviews were supplemented by observation of both the work environment and people working in the environment. In addition to these, related documents were examined.

The study commenced with literature review on LPS and CP. The purpose of this was to identify production planning practices and the underlying principles of LPS. Based on the literature review, an interview instrument was developed. The first section contained questions on the background of the respondents, while in section 2, the questions centred on the current views and practice of LPS and CP. The questions were open ended to allow the respondents to consider the phenomenon under investigation, to reduce bias and to improve the richness of the findings. However, the questions were structured to keep the respondents on track.

Thirty in-depth interviews were conducted over a period of 12 months comprising 18 main contractors, 2 clients, 4 lean construction consultants, and 6 subcontractors. The interviewees were drawn from across the various sectors in the UK construction specifically, 22 in England, 5 in Scotland, 3 in Wales. Majority of the respondents are in England because most of the top UK companies investigated have their head offices and major on-going projects in England. The authors were constrained and unable to interview respondent from Northern Ireland. All respondents interviewed had over 3 years' experience in the use of LPS and CP and were drawn from building construction, highways and infrastructures and rail sectors. The duration of each interview varied from 60 to 90 minutes. Notes were taken in the interview diary, and an audio recording was also done to uphold the validity of the process. Convenience purposive sampling was adopted for the study. Convenience purposive sampling was deemed appropriate for this study as there was no formal database for lean construction practitioners in the UK (Teddie and Yu, 2007). Also, this ensured that only those with experience in production planning practice participated in the study.

The recorded interviews were transcribed verbatim. The collated data were grouped into data sets and analysed via content analysis and coding process. In doing this, the data was categorised based on qualitative data analysis techniques after Miles and Huberman (1984). The code and themes for study were developed based on (A) the interview questions and (B) emerging themes recognised from the transcribed interview. The analysis used both inductive and abductive approaches; this implies that there was continual cross evaluation of the current practice of LPS and CP observed in the UK with theories of PPM (Dubois and Gadde, 2002). While an inductive approach entails making meaning from the analysis to generate theory, a deductive approach uses predetermined theory to explain the data obtained (Sporrong and Kadefors, 2014; Dubois and Gadde, 2002). An abductive approach on the other hand is the third form of inference that seeks the simplest explanation for observations. Sober (2001)

describes abductive reasoning as the "inference to the best explanation". This approach was adopted as it allowed the study to gain new theoretical insight through the empirical data and the established theoretical model of the LPS (Sporrong and Kadefors, 2014; Dubois and Gadde, 2002)

In addition to the 30 interviews, 15 projects were observed comprising 8 Highways & Infrastructure projects, 5 Building, and 2 Rail projects. The observation document was developed from published implementations of the LPS on several construction projects (Bernardes and Formoso, 2002; Sterzi *et al.,* 2007). The identified practices have been used to examine the implementation of PPM in relation to the LPS on construction projects including 12 projects in Israel (Priven and Sacks, 2015); 6 case study projects in Brazil (Bernardes and Formoso 2002) and in observing 5 projects in Brazil (Sterzi *et al.,* 2007). These documented researches have the capacity to reveal LPS implementation efficacy (Sterzi *et al.,* 2007; Bernardes and Formoso, 2002). The observation instrument used had three scales; full implementation, partial implementation and no implementation to capture the state of current implementation on the projects sampled (Bernardes and Formoso, 2002; Sterzi *et al.,* 2007). The three point Likert scale was adopted as this is a snapshot study to capture production planning practices on the projects observed and to also reduce response bias. Dolnicar *et al.,* (2011); Paulhus, (1991) observed from their study that 5-7 point Likert scale suffers from response bias. The findings from the interviews, observations, and document analysis are presented below.

4.0 Results and analysis

Except where otherwise stated "Collaborative Planning" (CP) refers to the UK PPM practice while "Last Planner System" (LPS) refers to the PPM practice in construction as evidenced from theory and practice internationally.

4.1 *Background of respondents*

Table 1 gives an overview of the distribution of the respondents across the 3 sectors (Building, Highways and Infrastructure, and Rail) considered in the study. This suggests that the findings from this study should broadly reflect the current practice of PPM in the UK construction industry. Also, since all the major stakeholders are represented in the interviews, the level of bias in the findings is reduced and objectivity improved. In terms of the interviewee's experience, Table 1 reveals that majority of the respondents had over 15 years' experience in the construction industry. Also, most of the respondents claimed to have over 5 years' experience in PPM practice in construction.

Table 1: Descriptions and distribution of interviewees across the UK construction sector

Respondents Code	Sector	Years of experience in LPS/CP	Years of experience in construction
MC01	Highways and Infrastructure	5	18
MC02	Highways and Infrastructure	3	17
MC03	Highways and Infrastructure	4	15
MC04	Highways and Infrastructure	4	6
MC05	Highways and Infrastructure	5	11
MC06	Highways and Infrastructure	5	10
MC07	Highways and Infrastructure	4	10
MC08	Building	10	10
MC09	Building	10	30
MC10	Building	12	20
MC11	Building	5	15
MC12	Building	6	15
MC13	Highways and Infrastructure	6	18
MC14	Highways and Infrastructure	5	10
MC15	Highways and Infrastructure	4	30
MC16	Rail and Infrastructure	12	4
MC17	Rail and Infrastructure	3	30
MC18	Building	4	20
SC01	Highways and Infrastructure	5	21
SC02	Highways and Infrastructure	4	20
SC03	Building	6	15
SC04	Highways and Infrastructure	4	10
SC05	Building	5	15
SC06	Highways and Infrastructure	3	6
CO01	All the sector	10	32
CO02	All the sector	14	26
CO03	All the sector	15	15
CO04	All the sector	10	20
CL01	Building	3	11
CL02	Highways and Infrastructure	10	30

MC= Main contractor, SC subcontractor, CO= Consultants, CL= Client

This suggests that the respondents have some knowledge of the practice of PPM and other project control practices in UK construction. The respondents occupy various posts such as planner/programme managers, lean deployment manager, construction and operation director, project manager, site engineer and improvement managers among others.

4.2 Use of the terms "Collaborative Planning" and "Last Planner System"

The study reveals that there is confusion over the use of the terms "Last Planner System" and "Collaborative Planning" in the UK. Respondents all recognised the term CP and approximately 50% recognised the term "LPS" although often calling it simply "Last Planner". Some respondents used the terms CP and LPS interchangeably without any distinction in meaning. Some of the respondents stated that they were not using the term due to the trademark on the LPS. Here are some of the transcripts: *"We are not using the term 'Last Planner' on our*

project because of the trademark on it, we choose to call it collaborative planning, it is easier for the team to understand" **(MC02)**, *"To us here, collaborative planning and last planner are the same, we take the principles of the last planner to suit our project" (***MC08**) *"Collaborative planning is the name for LPS in the UK"* (**CO01**)*.*

To understand this confusion of terms, it is worth noting that majority of the respondents had received some form of support from external lean construction consultants before the application of PPM principles on their projects. These consultants do not as a rule use the term "Last Planner System" because the trademark registered in the USA by Lean Construction Institute prohibits unregistered consultants from selling LPS training and consultancy (U.S. Patent No. 3020113, 2005). However, regarding the direct impact of the US trademark on UK practitioners, the information available from the United State Patent and Trademark Office (USTPO) indicate that: a mark is only protected in the country where it is registered except if such mark is registered in another country under the international Madrid protocol (USPTO, 2016). Also, Trademark legal practitioners have also offered explanation on the impact of a mark in a country outside it registration. For instance BITLAW state that:

> *"A mark is infringed under U.S. trademark law when another person uses a device (a mark) so as to cause confusion as to the source or sponsorship of the goods or services involved. Multiple parties may use the same mark only where the goods of the parties are not so similar as to cause confusion among consumers. Where a mark is protected only under common law trademark rights, the same marks can be used where there is no geographic overlap in the use of the marks. Federally registered marks have a nation-wide geographic scope, and hence are protected throughout the United States" (BITLAW, 2015).*

All of the above statements suggest that the direct impact of the US trademark on UK practitioners is more about perception than legally valid restriction. Also, Last Planner has a registered trademark in the EU (EU Patent No. 004516324, 2006). However, most of the practitioners interviewed were not aware of the EU trademark and only made reference to the US trademark. The impact of the trademark registered in the EU is unclear and is currently being contested by the LCI (EU Patent No. 013369863, 2014).This does not entirely explain the confusion in terms as other names such as "plan to save", "detail planning to completion", and "interactive planning" among others were also used. Also, some of the consultants still use the term "Last Planner".

Furthermore, most of the respondents agreed that CP is based on the LPS, while other respondents argued that there are other practices advocated in CP in the UK that are not in the LPS. For instance, one respondent stated that: "*To me LPS and CP are the same, but there is an amalgamation of other practices in CP such as the visual management that is not in the LPS"* **(CO02)***.* This further underlines the confusion around the practice as visual management is an established lean production practice (Liker 2004) directly imported from the

automotive sector into lean construction and can support both CP and LPS equally if required.

4.3 Time and programme compression

Most of the respondents interviewed agreed that CP focuses on programme and time compression of construction activities. One of the respondents stated that: *"The CP has been helping us to reduce our programme significantly, we enjoy twice as fast delivery of our process with CP"* **(MC06)**. Furthermore, most of the respondents interviewed indicated they used collaborative programming/phase scheduling, and Weekly Work Planning meetings. However, other elements of the LPS such as the make-ready process, look-ahead planning, constraint analysis, consideration for flow and learning with action were not mentioned or demonstrated as much. One of the respondents stated that "*We are not doing all the bits, the site people are too busy, we only do high level collaborative programming"* **(MC05)**. The emphasis on time reduction in the use of CP tends to confirm the speculation by Sarhan and Fox, (2013). Limiting the use of LPS to time reduction alone is narrow and limit the benefits which could be gained from it use, since the goal of the LPS is not only programme and time compression. For instance, a review of the International Group for Lean Construction's (IGLC) papers on LPS implementation revealed that the main focus of the LPS is reducing variability and increasing certainty in construction workflow rather than programme compression (Daniel *et al.,* 2015). This is not to say that the implementation of the LPS does not lead to reduction in construction programme, as previous studies such as (Alarcon and Calderon, 2003) among others have reported.

4.4 Common understanding of construction programme

The study reveals that the CP process is viewed as an avenue to understand and develop a sound construction logic that is often lacking when the traditional project management approach is used. Some of the interviewees stated that: "*It (CP) raises the awareness of collaboration among the supply chain. Usually, we expect the supply chain to deliver our programme even without involving them but now CP makes it better"* **(MC02)**; "*We get ideas from the supply chain to develop a more workable programme"* **(CL01)**. This suggests that the CP as practiced enables the project team to develop a better understanding of the relationship between activities on the programme. According to Pasquire (2012), for construction projects to flow as expected, all stakeholders need to have a common understanding of the tasks to be executed. This implies that the conversations that occur during the CP process have the potential to develop collaborative relationships among the project stakeholders thus helping to reduce fragmentation and engender stable workflow (Gonzalez *et al.,* 2015).

4.5 Intervention measures

The study shows that CP is commonly used in UK construction when there are signs of failure on a project, especially in meeting the time requirement. For instance, some of the respondents stated that: *"Our management decided we use (LPS and) CP on this project because of the failure of our previous process, we have rebased this programme many times. We have been working in isolation"* **(MC16)**. *"The key driver is the MD, because things are not going as*

initially planned" **(MC17)**. This is an indication that CP is used as an intervention measure rather than for transformation of the business process. The danger with such approach is that the organisation will only reap a one-off (and overall less) benefit from the practice. Additionally, the statements indicate that construction clients are not the only driver of the process, higher management from the contracting firm has an influence too.

4.6 Client and public sector demand as core drivers of CP in the UK

Most of the respondents interviewed stated that the demand from the client and the public sector are the major drivers for the use of CP in the UK. A respondent stated that *"We are working to achieve our client's expectations; we are required to use it on this project. Also, we have a drive for efficiency within our organisation for continuous process improvement"* **(MC03)**. The drive coming from the client and public sector in the UK seems contrary to what is commonly reported in other parts of the world such as the USA and Brazil. In those places, contractors are the active agent in initiating and deploying the LPS in their businesses (Alarcon and Calderon, 2003). It can be argued that, the slow and partial uptake of CP practice and PPM in the UK could be due to the push for the use of the system by the client and public sector rather than an internal motivation or pull from within the contractors. Although, the pace of uptake within the UK is slow, it has also been observed that the uptake of lean production principles in construction is slow globally (Stevens, 2014).

4.7 The Physical environment and document analysis

On all the projects observed, a designated meeting space is provided for CP meetings, which is usually tagged "CP" meeting room. Most of the projects observed made provision for a permanent collaborative programming or pull planning board and used either sticky-notes on the board for scheduling of activities or other temporary markers of different colours. Magnetic collaborative programming boards were used on some projects to provide a more robust working medium while other projects were working towards using electronic collaborative programming boards.

In addition to the less regular collaborative programming meetings, Weekly Work Planning meetings are also held. However, on some of the projects observed, the activities within these meetings had become fragmented to the extent that they were separated out into additional meetings with a different team of people, for example look-ahead activities taking place in a separate meeting from make-ready activities. The use of a form of visual management (VM) to communicate progress was seen on some of the projects. Document analysis revealed that the collaborative programme/phase planning is usually developed from the Primavera programme known as P6, generally considered as the contract programme.

4.6 Practices observed

To identify how the current practice of "CP" for delivering construction projects (as production) in the UK aligns with the LPS, 17 major practices associated with the implementation of LPS were identified. These are presented in Figure 2 along with the incidences of observed practice. It can be seen that

only one practice is fully implemented at 86% on all the projects observed: '*having initial collaborative planning/phase scheduling meetings',* whilst five practices are fully implemented on between 40 – 80% of the projects observed: '*measurement of Percentage of Planned (Promised) Complete (PPC)'*; '*Weekly Work Plan (WWP) meetings'*; *'planning and control process standardisation', involvement of subcontractors'* and *'look-ahead planning'.* It can also be seen that recording of '*reasons for non-completion (RNC) of task'* was fully implemented on 53% of the projects observed. However, the full implementation of a '*formal system to take action on the RNC of tasks'* practice was not observed on any of the projects. It was however partially observed on 53% of the projects with 46% lacking any evidence of implementation at all.

The study also identifies other practices that were absent on 40% – 80% of the projects observed. These include '*programming a workable backlog'; 'a lack of consideration for flow'; 'analysis of physical flow', 'use of prototype/first run study', 'make ready and constraint removal'* and '*formal communication of feedback to the supply chain'*. Analysis of physical flows focuses on the criteria for tasks to be included in a production plan (such as information, materials, tools, equipment, prior work, people, external conditions). Detail consideration for flow focuses on what needs to be done when there is a change in the production. For instance, the respondents were asked; what do you do when a task is completed earlier than planned? Some of the respondents said (a) "we do nothing", (b) "we re-plan", (c) we take it as bonus. Responses (a) and (c) show that there is no detailed consideration for maintaining synchronised work flow. The respondents interviewed here failed to recognise that some changes have occurred in production which needs to be addressed either by re-planning, increasing, or decreasing resource in order to keep production stable and prevent a knock-on effect.

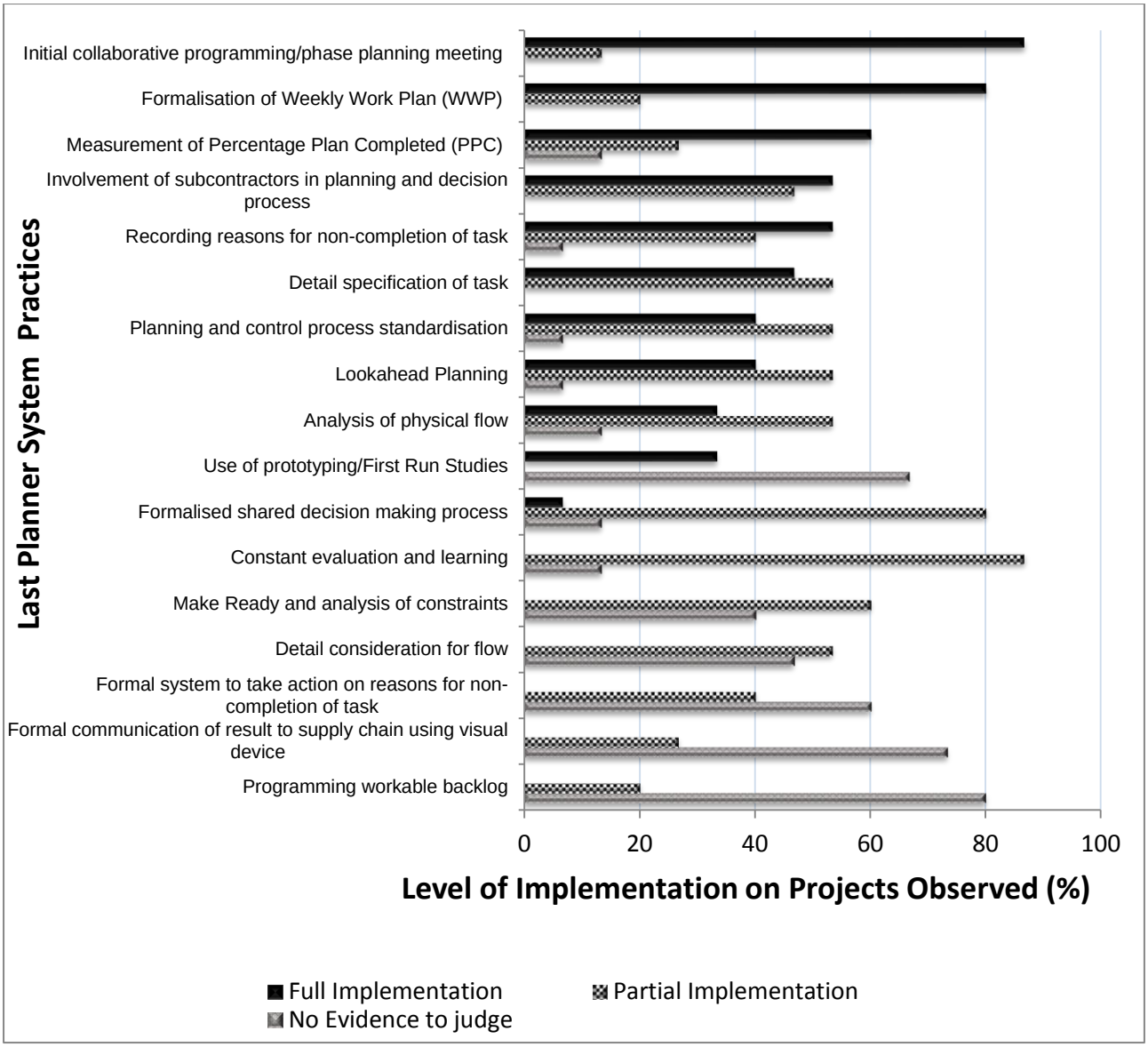

Figure 2: Level of implementation of Last Planner System principles on projects observed.

Although the graph shows something of all the LPS principles (except one) implemented on the projects observed, this implementation was fragmented with no single project implementing all the principles. The most comprehensive implementation observed was 60% of the principles on a single project. The degree to which the observed practices map across to components of LPS is shown in Figure 3.

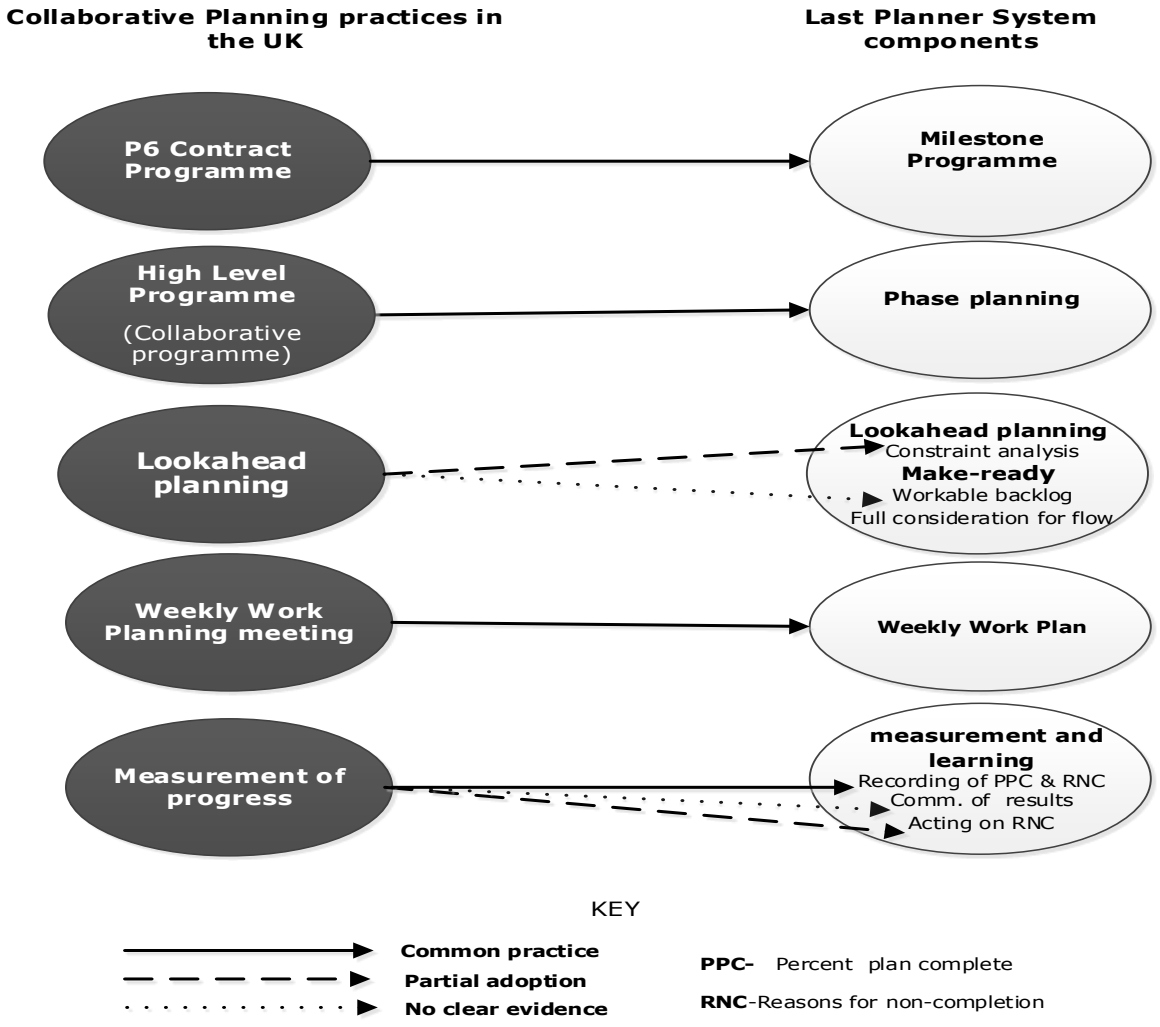

Figure 3: Comparing Collaborative Planning practice in the UK with the Last Planner System Components

Figure 3 shows a strong correlation between the current practice and the LPS at Contract/Milestone programme and the high-level programme/phase planning elements. There is equally a strong relationship at the levels of recording PPC and RNC. However, there is partial adoption in the WWP on some of the projects observed. For instance, WWP was only supplemented with daily huddle meetings on few projects, and as observed, in these cases, the daily huddle meeting is more of activity reporting rather than an avenue to make needed adjustments to tasks that are slipping off schedule. The depth of application of the more complex attributes contained in the LPS is weak or missing. Figure 3 clearly shows that there is only partial alignment of current CP practice to the elements of the LPS on the projects observed.

5.0 Discussion

All the interviewees felt the CP approach offered benefit. In general, not formally implementing the full range of components within the LPS means maximum benefit is not being realised. The comparison of current practice of CP with the

LPS components in Figure 3 partially aligns with practice elsewhere in the world. Previous studies such as (Daniel *et al.,* 2015; Sterzi *et al.,* 2007; Bernardes, and Formoso, 2002) show the measurement of PPC, WWP meetings (short-term planning) and collaborative programming/phase scheduling to be among the elements of the LPS most consistently reported as implemented in previous studies published by the IGLC[3]. However, the practices varied in detail from one project to another. While CP was done with full involvement of the supply chain on some projects, on other projects, the supply chain were only partially involved as revealed by the interview results. For instance, a senior planner interviewed on **MC03** stated that: "*We only involve the principal subcontractors in the collaborative programming, we plan and give the programme to the smaller subcontractors".* This implies that not all the supply chain was involved in developing the high-level collaborative programme. Furthermore, gauging the current CP practice with the Last Planner prescriptions such as planning backwards, defining plan scope by the players involved, narrowing scope when needed to untie knots, building floats into plans and allocating them to risky and critical tasks, (Ballard, 2000), reveals they only occur partly on some of the projects observed. CP as practiced tends to only provide the platform for stakeholders to have conversations on the proposed schedule and is deficient in the process rigor as prescribed in the LPS. This is due to too much focus on the execution of tasks and the absence of robust supporting mechanisms to enable flow in the approach.

Clearly a number of key LPS elements are missing in the present approach. The most apparent of these is the lack of formal action on the RNC recorded. For example, an interviewee stated that *"We used to log the reason for non-completion of task into an excel sheet but we have not developed any formal approach for analysing this data"* **(MC07)**. According to Ballard, (2000) the purpose of recording RNC in the LPS is to enable the team to collectively act to address the identified issues and to prevent future occurrence, which enhances learning. It can be argued that if no formal actions are taken to address the RNC recorded, then the recording itself becomes a waste of time and resources. Typical action on RNC should include at least a formal root cause analysis. That no collaborative actions (either formally or informally) are taken on the reason for non-completion recorded removes the opportunity to generate innovation, provide learning, enable action and improve collaboration among the project stakeholders.

Other missing elements are the development of a workable backlog (Plan B) and the consideration for flow that form part of the make-ready process in the LPS. The lack of consideration and analysis of flow was evident on most of the projects evaluated. For instance, during the interview, one of the respondents was asked; *"what action do you take when an action is completed earlier than planned?"* The response is "*we don't do anything; we take it as a bonus*" **(MC01)**. This shows a lack of understanding of flow and the importance of load levelling and stability in the production process once the phase plan is agreed. Unplanned early completion is most likely to be a benefit for a contractor who is only managing the sub-contract packages but to be at least benefit neutral or a detriment to sub-contractors as it increases uncertainty across their

[3] International Group for Lean Construction www.iglc.net

multi-project environment. When the focus of the production system is shifted from the management of workflow to the pursuit of cost and/or time reduction, the entire production system could collapse (Conte *et al.,* 1998).

It can be argued that the prevailing practice of CP focuses more on time reduction and programme reduction than achieving a smooth workflow across the project. Finishing early is most likely to be the result of planning too little work in the first place or from the removal of a constraint not identified in the make-ready process which has permitted work that does not meet the four criteria (sound, sized, sequenced, and detailed) into the WWP. It is clear then that a reduced make-ready process that sends work to the work phase (weekly or daily) without meeting the four criteria of production planning results in reduced productivity and associated programme and margin slippage (Court *et al.,* 2009). It is important to note that PPC is a predictor of productivity because of the 4 requirements for a committable task; i.e., sound, sequenced, sized, and well defined (see Liu and Ballard, 2008, Ballard, 1999). However, PPC can be 100% and the project still behind schedule because work is not being made ready in the right sequence and rate (Hamzeh, *et al.*, 2012).

Related to the make-ready process is the look-ahead process. Observation of this also indicated some limitation in practice, notably, a look-ahead window of two weeks was too short to allow sound assignments to be developed. Additionally, whilst metrics such as PPC, RNC were measured and recorded, these metrics were not formally communicated to the supply chain on some of the projects observed. For instance, one of the respondents stated "*We do not publish PPC and RNC to the subcontractors, if I am showing this to the subcontractors, I am going too low. We only make this available to the senior management team. Some of the subcontractors get confrontational and defensive about this, especially if the work was delayed by the main contractors"* **(MC08)**. This is another indication of a limit to the scale of adoption of collaborative practices despite the use of the term "CP" to describe the approach. The safeguarding practices observed appear to be deeply embedded in the prevailing practice and serve as a significant barrier to collaboration (Pasquire, Sarhan and King 2015)

6.0 Conclusions

The aim of this study is to identify how *Collaborative Planning* for delivering construction projects from the PPM perspective in the UK construction industry aligns with the advocated principles of the *Last Planner System* of production planning and control. The study established that the currents practice of CP as observed in the major sectors of the UK construction industry align with some of the generally advocated principles of the LPS acknowledged in the literature; specifically, the high level collaborative programming, WWP meetings, and the measurement of PPC and the charting RNC. There was no intention for this study to evaluate or measure the success or otherwise of the practices observed. However, the study reveals that the current practice of CP in the UK has not explored all components of the LPS. This situation inhibits the extent of benefit that can be realised and even the advancement of industry performance. The study reveals that the message coming from some UK lean construction consultants on LPS is mixed at best and distorted at worst, thus limiting the comprehensive adoption of the system in the UK.

The components not used include look-ahead planning; aspects of the make-ready process such as consideration for workflow and developing a workable backlog; and acting on reasons for non-completion of tasks among others. Furthermore, the absence of these elements indicates a poor understanding of construction as a production process and the importance of flow in successful project delivery and benefit realisation.

Of greater concern is evidence of a continuing subtle resistance to meaningful collaboration across the project supply chain illustrated by inadequate sharing of information and benefit. This suggests the continuing influence of the traditional project management command and control approach, in which the supply chain is not consulted or informed adequately. This influence is further evidenced by the lack of deep and systematic actions to address the reasons for non-completion which hinders innovation and learning.

The study established that CP as a means of engaging people in decision making before the fact first surfaced in the 1960s and came into more common usage not long after that. This does not have a specific process or set of processes attached to it. The LPS entered more common usage in the 1990's and has a very specific set of processes attached to it. In the UK, CP is a term used to describe partial implementations of the LPS since mid-2000 and is now unknowingly used as such. The study recommends that the current practice of CP in the UK should be extended to include other elements of the LPS to reap greater benefit. This could be achieved by gauging the current implementation against the LPS model and constant evaluation of the implementation with PPM practice checklists.

Based on these findings, future studies should map the mismatches and the underlining barriers identified in detail, so as to develop a methodology to create a pre-disposition within project teams to enable a rapid and successful implementation of the LPS. This will form the next stage of this on-going research by the authors. Another area for future work is to examine the impact of the trademark on the LPS usage.

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