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THE USE OF FIRST RUN STUDIES TO DEVELOP STANDARD WORK IN LIQUEFIED NATURAL GAS PLANT REFURBISHMENT

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ABSTRACT

The refurbishment of existing Liquefied Natural Gas (LNG) plants is complex and potentially hazardous, so it is crucial that the workforce has the capability to undertake the work in an efficient and safe manner. One method to achieve this outcome is by the development of efficient work practices, fully utilising workforce experience and knowledge.

The purpose of this paper is to describe the outcomes resulting from the development and use of a lean tool referred to as Workshop First Run informed Work Design (WFRiWD) on the ongoing refurbishment of a Liquefied Natural Gas (LNG) plant in the North West region of Australia.

The paper identifies gaps in knowledge, where firstly there is little evidence of the use of a WFRS phase using existing resident knowledge to continuously develop and improve good practice. Secondly it addresses criticisms of the current issues the construction industry has in managing knowledge and thirdly it addressees the lack of literature and practice on the use of shared knowledge to enhance the development of high performance teams.

The tool has been developed and tested through Action Research cycles. The main result is the demonstration of how existing teams can evolve into higher performing teams using the WFRiWD tool in a collaborative knowledge sharing process.

KEYWORDS

First Run Studies, Work Design, Standardization, Deming wheel.

INTRODUCTION

This paper describes the use of planning workshops and first run studies to design and develop standard work for the refurbishment of LNG plants. The purpose of the planning workshops is for the engineers, superintendents, supervisors and leading hands to collaboratively conceptualise work designs which are then tested through site based First Run Studies (FRS) to develop improved standard work. This approach

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is one of a number of lean tools implemented on the refurbishment of the Karratha Gas Plant (KGP) in the Pilbara region of Western Australia.

The refurbishment is three years into an expected eight to thirteen year programme. The refurbishment works are being carried out under an Engineering, Procurement and, Construction Management (EPCM) form of contract. The facility itself is one of the largest integrated liquefied natural gas (LNG) plants in the world, contributing over 1% of GDP to the Australian economy. Working conditions are demanding with high summer temperatures experienced, rising to 45°C in the shade and above. Personnel operate for the most part on a fly in, fly out (FIFO) roster, usually on a two week on, two week off basis, operating in a back to back rotation system, where two people will rotate on the same job. This adds to the already complex work on live and offline process plant and makes for a challenging environment adversely impacting on productivity.

It is recognised that there are serious productivity deficiencies in the Australian oil and gas industry with an urgent need to better understand and then address the causes. Ellis, et al. (2013) report an escalation of costs over the last decade to a point where it can cost 20%-30% more to build in Australia than on comparable projects in North America. Lean tools have been implemented over a 17 month period to seek to address some of these productivity issues and engage the workforce in the sustainable embedment of a lean construction approach.

A literature search indicates a gap in knowledge where there is little academic or practitioner discussion on the use of a planning stage, allowing prototypes to be developed prior to testing on site in a FRS. Nguyen, et al. (2009) alone describes the use of a Virtual First Run Study (VFRS) as a distinct planning stage where prototypical solutions were developed for a viscous damping beam. In this instance the methods used were 4D simulation, integrated team coordinated meetings, process mapping and choosing by advantages (CBA). In the implementation described herein, integrated team workshops, process mapping and some 3D modelling are used in the planning stage. To differentiate the planning stage is referred to as Workshop First Run Studies (WFRS) with the combined tool called Workshop First Run Studies informed Work Design (WFRiWD).

WFRiWD combines planning workshops using resident knowledge to collaboratively develop prototypes, followed by FRS where the prototypes are tested on site. Prototyping is used extensively in many industries but has largely been ignored in the construction industry. The prototypes are standard work designs which Ballard (2014) says are “an explicit detailed plan for how a specific task will be done, developed collaboratively by those who will do the work”.

The WFRiWD tool utilizes the knowledge of the workforce. The importance of Knowledge Management (KM), involving the efficient flow of tacit and explicit knowledge within an organization has become increasingly important in the post-industrial era. There is a realization (Robinson, et al., 2005) of the need to be aware of the relative importance of tacit and explicit knowledge usage in the construction process with an understanding that tacit knowledge is of greater strategic importance than explicit in relation to business performance (Chen and Mohamed, 2010). Explicit knowledge can be codified but tacit knowledge (Polanyi, 1966) in a non-verbalized form of knowledge which is extremely hard if not impossible to codify. There is a fixation in construction on collecting “lessons learned” at the end of work, to codify all knowledge and develop “best practice” for use on future contracts (Carrillo, et al., 2013). However construction companies struggle to successful realize the potential of KM using this approach. The lessons experienced and “learned” are rarely successfully reintroduced (Paranagamage, et al., 2012), become lost in storage systems (Carrillo, et al., 2011) and IT is not capable of capturing tacit knowledge without losing its context (Malhotra, 2000).

Newell, et al. (2009), notes that “best practice” is a socio-political process of negotiation rather than an objective reality, the implementation of which leads to “vanilla” solutions, and that “skilled artisans will fiercely resist having their hard won tacit skills reduced and ‘fossilized’ in a process of codification” needed to develop “best practice” (Boisot, 1998: p 47). The outcomes from the current KM approach in the construction industry are underwhelming particularly with regard to effective knowledge transfer among and between teams.

Orlikowski (2006) refers to a “scaffolding of knowledgeability” which supports the transfer of knowledge between teams. The scaffolding denotes a broad class of physical, cognitive and social tools that allow teams to accomplish goals which would otherwise be beyond them (Clark, 2002). Nicolini, et al., (2012) describe tools or objects used in the transfer of knowledge and understanding in cross-disciplinary collaboration. These are referred to as boundary objects. This concept was developed within the field of science studies (Carlile, 2004; Levina, 2005) and boundary objects are described as being defined by their capacity to serve as bridges between intersecting social and cultural worlds. A range of objects can become boundary objects, including standardized forms, sketches and drawings (Carlile, 2002), physical objects, prototypes (Star and Greismer, 1989) and narratives (Bartel and Garud, 2003).

The paper discusses the development of high performance teams from existing ones when resident knowledge and experience is utilized in the WFRiWD process to continuously develop and embed good practice in the form of standard work. Chinowsky, et al. (2008) notes that high performance teams receive little attention in the construction industry. These teams exceed standard industry benchmarks by the development of an ability to continuously exchange knowledge and insights among the team. The paper reports on two different action research cycles where existing teams evolved into higher performing teams in the course of the implementation of the WFRiWD process. The WFRiWD tool was implemented alongside a number of lean tools, to directly address among other things, shortfalls in current construction KM practice. These teams consisted mainly of supervisors and leading hands using the tool collaboratively, sharing knowledge and insights to develop continuously improved standard work.

The aim of this paper is to report on the implementation of the WFRiWD process and in so doing address the gaps in the literature which includes the paucity of research in the use of planning workshops in the development of standard work design, the issues construction organisations experience in the successful use of KM and the lack of discussion directing the evolution of high performance teams in construction environments.

The outcomes showed how the teams implemented the tool often requiring a low level of researcher (lead author) input, displaying an innate awareness of Deming wheel concepts despite having no previous formal exposure to the concepts.

WORKSHOPS AND IMPLEMENTATION

The implementation of the WFRiWD used the guidance of Ballard and Howell (1997: pages 125-126) who say that the planning and implementation exercise should be carried out as follows in order to develop standard work packages:

Plan

1. Select the work processes to study.
2. Gather the people for the planning phase who can provide input and impact.
3. Collaborate using past experience to develop good practice.
4. Anticipate hazards and specify preventions.
5. Assign optimum labour, tool and equipment resources.

Do

6. Try out the prototyped work in the FRS phase.

Check

7. Describe and measure what actually happened, process steps, durations, errors, omissions and reworks, near misses and hazards, resources used and outputs.

Act

8. Reconvene the team, especially those involved in carrying out the work. Review data and share experiences. Continue to refine the standardised work.
9. Communicate the improved standardised approach to the workforce.

Ballard and Howell (1997, p. 215) note that “the intent is to thoroughly plan and study first run studies of operations, using past studies as guidelines and producing standard work method designs for use on the project. This experiment – based approach produces a tested method that can be taught to all crews, thus reducing cost, errors and accidents... once workers see that you are interested in finding better ways of doing work, they will develop and share their ideas”.

METHODS

The research used an action research (AR) approach. Action research uses action – reflection cycles in a process of observe-reflect-act –evaluate- modify – move in a new direction. Coughlan et al note that action research uses

“A scientific approach to study the resolution of important or organizational issues together with those who experience these issues directly. The goal is to make that action more effective while simultaneously building up a body of scientific knowledge” (2009: p. 5).

During the course of the primary research, action research was used to implement change by the use of lean tools including the LPS and WFRiWD. The AR process included organizing the required meetings and workshops and then facilitating and mentoring people during the course of the implementation. The AR was cyclical and iterative in nature with the outcomes from one cycle informing the development of the plan in the following cycle. The AR cycles were implemented over a 17 month time period.

DEVELOPMENT OF THE BOUNDARY OBJECTS

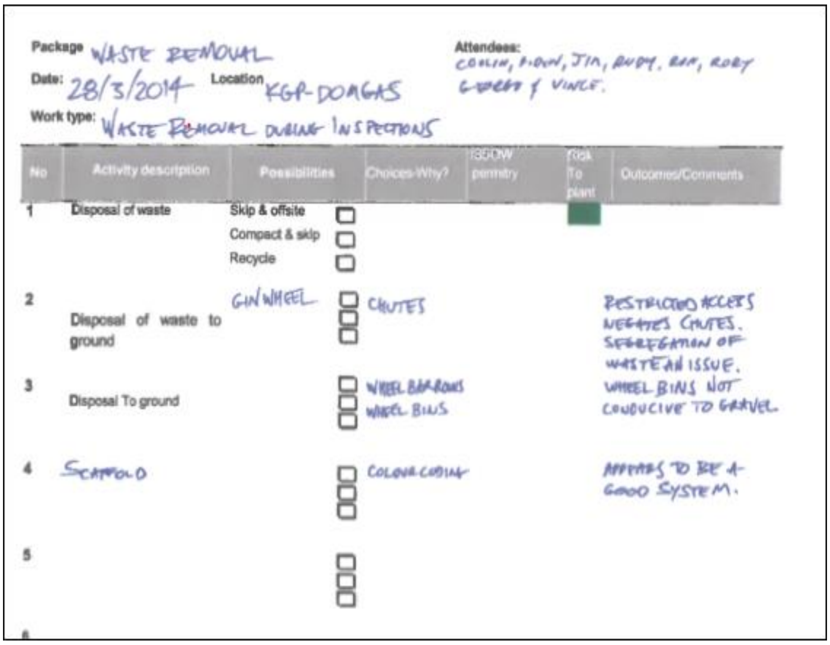
Much of the early implementation work involved the identification of the most appropriate boundary objects. As discussed above boundary objects may be artefacts or narratives that aid transfer of knowledge and the formation of common understanding (Pasquire, 2012) between interrelated teams.

The WFRiWD tool was implemented alongside the Last Planner® System (LPS). Whilst the use of the LPS has been well documented and understood over the last two decades there is little literature on the implementation of FRS informed by a stand-alone planning phase as a part of the iterative Deming Wheel cycles.

A number of workshops involving engineers, superintendents and supervisors were undertaken to identify the most suitable boundary objects to most efficiently transfer knowledge in the development of standard work design. The first workshop explored the use of a pro-forma (figure 1), to develop standard work design for inspection work scopes. The workshop demonstrated that the pro-forma had some drawbacks in that it limited the collaborative potential of the teams.

Following analysis of the outcomes of the first workshop, a revised boundary object was used in subsequent workshops where whiteboards and post-its were used. This facilitated discussion between the participants, so identifying good practice and potential improvements for example in inspections undertaken from rope access and scaffolding.

The workshop consisted of the visual tracking of the work involved in inspection from ropes and scaffoldings. The main takeaway from these workshops was that good practice was identified, the workforces were willing to engage in the workshops and that the most suitable boundary object was the white board (Figure 2).


Package: WASTE REMOVAL
Date: 28/3/2014 Location: KGP-DOMGAS
Work type: WASTE REMOVAL DURING INSPECTIONS
Attendees: [illegible]

No	Activity description	Possibilities	Choices-Why?	ISSOW permitry	Risk To plant	Outcomes/Comments
1	Disposal of waste	Skip & offsite Compact & skip Recycle				
2	Disposal of waste to ground	GIN WHEEL	CHUTES			RESTRICTED ACCESS NEGATES CHUTES. SEGREGATION OF WASTE AN ISSUE.
3	Disposal To ground		WHEEL BARROWS WHEEL BINS			WHEEL BINS NOT CONDUCIVE TO GRAVEL.
4	SCAFFOLD		COLOUR CODING			APPEARS TO BE A GOOD SYSTEM.
5						

Figure 1. WFRS pro-forma

The boundary object used during the course of the workshops to transfer tacit knowledge was the use of narratives. Another boundary object used was the interactions and discussions of the interrelated teams as they worked together on the work fronts.

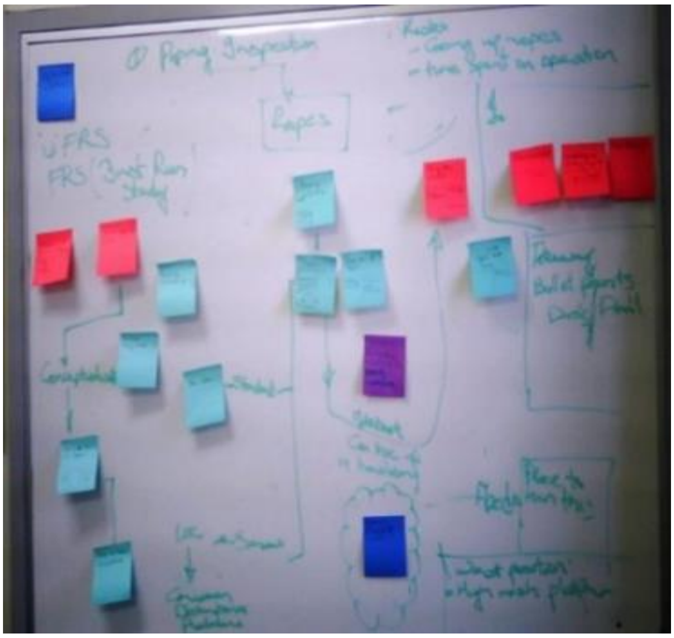


Figure 2. White board with post –its

ACTION RESEARCH: IMPLEMENTATION OF WFRIWD

In order to ensure the sustainable development of the high performance teams, the development and use of the WFRiWD tools was led by teams, aided by some researcher facilitation in the following situations:

- Workshops informed by questionnaires
- Continuous Improvement cycles by the workforce

Workshops informed by Questionnaires

This approach was used by the inspectors involved in diagnosing and developing the ongoing plant refurbishment scope of work. The inspectors work in small teams and display a unique array of skills. The inspections are undertaken mostly from rope access. The nature and complexity of the inspections and reporting demands a high degree of physical and mental dexterity. As a result inspection teams comprise people who are physically and mentally resilient, who will only engage with change when it is seen to have potential value. The WFRiWD was accepted as a tool that would provide improved outcomes.

The boundary object first employed was a white board with post-it's using a pull-planning format. The outcomes were implemented on site and refined using the PDCA cycle.

Ongoing discussions with the inspectors supported the hypothesis that a high level of tacit and explicit knowledge resides in the workforce consciousness. This provided a rich source of knowledge informing the workshops. The lead inspection engineer, an early lean construction adopter developed a questionnaire to tap into the workforce experience and knowledge. The feedback from the questionnaires, (example Figure 3), provided rich information informing the WFRS phase. There were 11 areas addressed with "key takeaways" developed for further work-shopping.

EPCM Key Takeaway:

The integration of the Last Planner System has provided the implementation contractor with the opportunity to own the schedule.

The sporadic and late delivery of work- packs hindered the ability to correct plan and manage the scope.

Changes in priorities affect productivity, having to mobilize personnel to different areas of the plant to meet imminent deadlines is best avoided through sufficient planning.

Figure 3. Questionnaire Key Takeaway

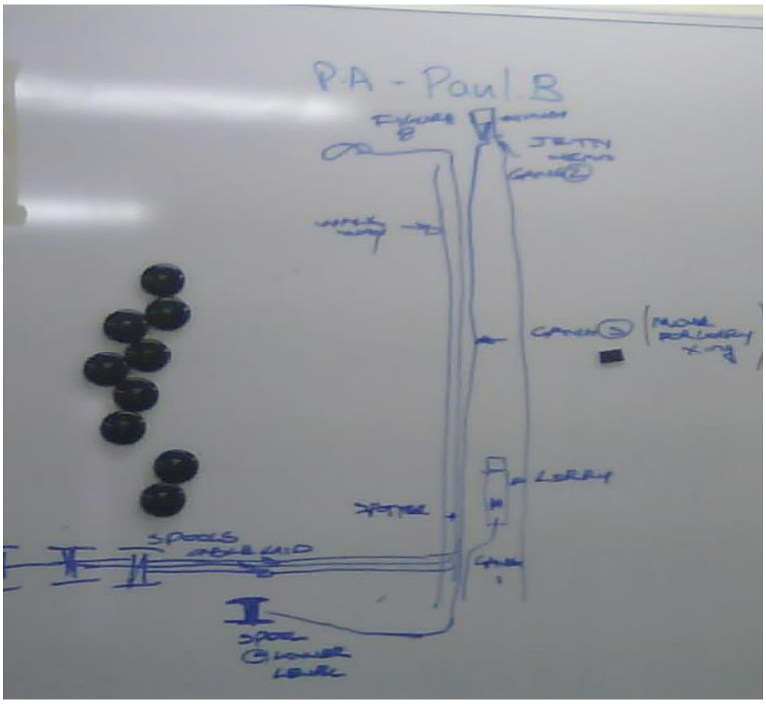


Figure 4. WFRS on white board

This approach addresses criticisms of current organizational knowledge management (KM) discussed previously. Here KM is contemporaneous, using the workforce knowledge and engagement to develop continuously improving standard work.

WFRiWD led by the Workforce

The WFRiWD lean tool was implemented along with the LPS by the workforce on jetty refurbishment scope. The jetty is a key installation used to load product to ships for export to market. In this instance the workforce was already using the LPS and also used a WFRiWD type tool.

The work scope was complex, including civil, electrical and mechanical scope with inherent hazards and restrictions due to the ongoing loading of ships with hydrocarbon product. These constraints meant that the workforce had to continuously develop and improve the work design to maintain efficient workflow.

A particular work scope was the installation of power and instrumentation cabling. The conceptualized work design was initially developed by the supervision using a white board (figure 4). The outcome from this workshop was implemented on site in a FRS (figure 5).

Figure 5. Use of winch *Figure 6 . Use of Lorry*

The initial FRS and subsequent iterations of the WFRiWD identified improvements, which included the use of a wagon to assist in the cable laying operation (figure 6). This was deceptively complex work and the methodology was refined through ongoing iterations of the WFRiWD. In this way the workforce was able to improve production considerable and also improve safety and quality outcomes. The work groups continued to use this approach to develop and optimize standard work for the ongoing jetty scope of work.

It is significant that the contractor's construction supervisor could describe the methodology he used. He described the philosophy and process as follows: Firstly he (MP, the implementation contractor's supervisor) walks the course with his leading hands (LHs) and they talk through how they are going to do the work. He will suggest a method to get the discussion going, they may come up with a different approach, and by doing this he is getting a buy in from the LH's. For instance on pulling the cables from the drums. MP wanted to leave the cables on the drums and go through the stairs, the LH's proposed an alternate route and method. The alternative solution was used and worked well.

The supervisors and LH's normally use the white board (figure 4) to draw up and get a visual on the work flow. The LH's then draw up the SWMS (safe work method statement) which is a simple bullet point description of the work. These are the outcomes from this approach as described by the supervisors involved:

- The LHs create the philosophy and develop the work design.
- The workforce know the job because they own it and built it.
- People sometimes struggle with complex drawings but understand the job from discussions and the visuals.
- The process gives a common sense of ownership to those involved.
- Relationships are strengthened as team members are tutored, coached and mentored in the walkthrough and team members build broader relationships with each other.

- Crew members understand each other's individual strengths and weaknesses as a result of the rich conversations that occur.
- Problems that are difficult to resolve are left by team consent with the commitment to come back later with a fresh perspective.
- The process delegates the work to the LH's and confirms the LH's understanding of both the scope and hazards.
- People discuss the productivity rates they will expect and take ownership of both process and what success looks like.

CONCLUSIONS

The study addressed the introduction and use of a tool described as WFRiWD. This tool uses a distinct WFRS phase in a Deming wheel cycle (PDCA) to develop work design that can then be tested by the workforce in on site FRS. By using ongoing iterations of the Deming wheel continuously improved standard work was developed.

The research addressed a number of gaps in knowledge. The first is that whilst FRS is a tool used in lean construction, when used it is normally there is no evidence of the use of a distinct planning phase. The gap was addressed by the development and use of a WFRiWD tools that employs a WFRS to develop conceptualized work design before introduction on site in a FRS to develop continuously improved standard work approaches. The WFRS workshop collaboratively draws in decision makers, using their tacit and explicit knowledge to build the conceptualized work designs. In this way knowledge and experience is being utilized to develop continuously improving good practice suitable to a particular environment, in this case the Karratha Gas Plant. The second gap is the lack of literature describing a successful use of KM in construction. This gap was addressed by the use of the WFRiWD process engaging the workforce to use their knowledge in the contemporaneous and continuous development of standard work at the work fronts. This third gap is the lack of literature on the development of high performance teams in construction, which was addressed by the development of higher performing teams using the WFRiWD tool as a mechanism to transfer knowledge among and between teams.

The research and implementation resulted in a number of outcomes which included the development of a formal process to use the WFRiWD tool. It also demonstrated the capabilities of the workforce to intuitively grasp the concepts of the Deming wheel and prove ability to lead the development of standard work. Other outcomes included the development of a site-based initiative using a workforce questionnaire to provide input for the workshops. The implementation also demonstrates the potential for the successful implementation of the tool particularly when supported by workforce engagement. All this aided the ongoing development of high performing teams. Higher performance was demonstrated by the ability to continually learn, improve workflow and achieve improving productivity levels above the site norms.

The limitations of the research is that to date the implementation has been carried out only on the refurbishment of LNG plant. There is a need to undertake further research on other types of construction to assess the outcomes from implementation of the WFRiWD tool.

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