

IS GOOD ENOUGH 'MAKING DO'? - AN INVESTIGATION OF INAPPROPRIATE PROCESSING IN A SMALL DESIGN AND BUILD COMPANY

Stephen Emmitt (1), Christine Pasquire (2), and Basant Mertia (3)

(1) Professor, Loughborough University, s.emmitt@lboro.ac.uk,

(2) Professor, Nottingham Trent University,

(3) KTP Associate, Loughborough University.

ABSTRACT

Purpose: The aim was to address behaviour that led to inappropriate processing in a small design and build contracting organisation that employs direct labour. The objective was to reduce process waste and improve the value delivered to clients. This formed part of a larger knowledge transfer project (KTP) to improve performance on construction sites through the application of lean thinking.

Methodology: Action research was used to identify and bring about change within the contracting organisation. The method was applied to live construction projects in the social housing sector in the greater London area. The intervention was to raise the awareness of site personnel to the importance of finishing tasks through informal discussions and visual management techniques.

Findings: Raised awareness of the importance of finishing work to allow other trades to follow on unimpeded led to significant improvements in the quality and flow of work. This helped to contribute to significant savings in time and cost.

Practical implications: This applied research is practical and cost effective to apply to live projects managed by small and medium sized contracting organisations.

Academic implications: the observations made reveal a form of waste in construction that has not been widely recognised in the literature on Lean.

Research limitations: Findings relate to a small SME with directly employed labour, therefore the findings have limited applicability. Further applied research is required to determine the generalisation of the approach/findings to organisations that subcontract their labour

Originality/value: Provides a unique insight into the practical application of lean thinking tools and process improvement.

Keywords: Lean thinking; Lean culture; Making do; Process improvement; Task completion; Work sequence (flow).

Paper Type: Research paper

INTRODUCTION

Originally developed in manufacturing (Womack et al, 1990), lean thinking has been applied to many sectors, including construction. Since the 1990s considerable effort has been expended on developing lean construction, promoted by the Lean Construction Institute and explored mainly via conferences organised by the International Group for Lean Construction (IGLC). The growing body of conference proceedings and articles contained in peer reviewed journals tend to report on work associated with large contracting organisations and large projects. Very little work has explored the application of lean thinking to small/medium enterprises (SMEs) or small construction projects. The gap in knowledge relating to SMEs and small construction projects is important given the large number of SMEs operating in the construction sector and the large number of small projects they manage. The aim of the work reported in this paper is to highlight some of the factors resulting from a knowledge transfer partnership (KTP) between a small design and build organisation and a university, both based in the UK. The objective is to illustrate some of the

challenges that are specific to small design and build organisations when trying to bring about improvements in their working practices by applying lean thinking.

KTP projects are part funded by the UK Government's Technology Strategy Board (TSB) and partly by a commercial/business organisation. This allows a KTP Associate to be employed by the university to work as an agent for change within the commercial organisation, applying knowledge to a practical challenge. In this KTP the project associate's role is to identify areas for improvement and make appropriate interventions, drawing on the knowledge and skills of the university to make informed decisions. The role of the university is to provide expertise and facilitate appropriate changes in the design and build organisation. This should result in improved performance within the business and the generation of new knowledge.

The case study company is a small design and build main contractor, operating within the social housing sector in the Greater London area. It employs its own workforce of project managers, site managers, plumbers, carpenters, bricklayers, decorators and other site operatives. Directly employing its own workforce has allowed the company to maintain and deliver work to high quality standards, through which it secures repeat work from social housing landlords. Based on the company's reputation for quality, the majority of its work comes through cost negotiations with clients, rather than through competitive tendering. Although the directors of the case study organisation claim that a directly employed workforce enables them to deliver high quality products; a directly employed workforce can also be a financial liability in relation to inefficiencies in the planning, supervision and execution of work.

The aim of this KTP was to embed a culture of continuous improvement within the contracting organisation by applying lean thinking. The objective was to address and eliminate inefficient working practices and make efficiency improvements. At the start of the KTP the design and build organisation had identified that in order to stay competitive they needed to address the flow of work on their construction sites. Senior managers and directors at the design and build organisation were aware that the handovers were problematic and trades were returning to units more often than they should. However, the extent and root causes of these problems had not been investigated prior to the start of the KTP. Hence the initial focus of the research was on construction site activities and the flow of directly employed trade packages. Early investigations into how work was conducted on the construction site revealed a tendency for the workforce to start work wherever and whenever it could. The result of this was that it often impacted on other trades and resulted in work that was not completely finished. It appeared that the workforce was completing just enough work to enable them then to start something else. There is then a need for someone to return to complete work that could and should have been done earlier, which causes disruption to the flow of work and is wasteful. A question arises over what sort of waste this way of working causes. It is proposed that there is a need to expand the current understanding of 'making-do' to include a sequencing of work that is 'good enough'.

'MAKING DO'

Making do was identified by Koskela (2004) as an eighth category of waste in construction projects, building on Ohno's (1988) seven categories. Making do is a form of waste that occurs when a task is started, even though one or more of its standard inputs are not available. As a result the task is not fully completed, leading to inefficiencies and waste because someone has to return to the task to finish it. Koskela (2004) referred to making do as a negative buffer where incomplete tasks are waiting for their standard input(s). These standard inputs include all seven flows

of construction as described by Koskela (2000) and generalised by Bertelsen *et al* (2007). The seven flows are: information; space; resources; previous work; materials; equipment; and external conditions. The eighth waste, making do, may also be considered as an under-processed inventory where any partly processed task is pending completion. It is a kind of waste that is invisible most of the time and difficult to measure (Koskela 2004); yet not impossible to mitigate or eliminate. Deeper investigation of 'making-do' by Formoso *et al* (2011) showed that in some instances starting work without all the inputs could be considered a beneficial problem solving improvisation in construction projects.

Koskela's (2004) initial analysis on making do helped to inform this research, in particular, directing the researchers to identify the root causes of why making do existed and its consequences within the design and build organisation. Koskela (2004) quotes Ronen (1992) and Grosfled-Nir and Ronen (1998), who presented two broad categories of consequences of making do. These are (i) technical consequences, which refer to the time, cost and quality of the task; and (ii) behavioural consequences, which refer to the loss in productivity of workers executing the task. Initial observations found that tradesmen and site managers seem to be starting work without the proper completion of earlier tasks. In other words, the flow of "previous work" is inadequate and thus falls into the current definition of 'making do'. However, further examination showed that the previous work was judged to be "good enough" to permit the next trade to start even though it was known the operatives would need to return to the location to continue later. This challenges the completeness of Koskela's definition of 'making-do' as it currently includes only the inputs for a task and doesn't consider the output. Koskela (2004) does describe partially complete work as 'making do' but only as a consequence of completion being prevented by inadequate inputs. This does not cover the phenomenon of the workforce choosing not to finish because they believe it is the appropriate action to take.

'Good Enough'

There are a number of theoretical examples where the execution of tasks can be 'good enough' to be considered finished. Serlin & Lapsley (1985 & 1993) propose the 'Good Enough Principle' in the field of psychological research wherein a statistical value needs to be within a range of acceptable results for it to be 'good enough' to make a valid conclusion. In this example the conclusion is the completed work and there would not necessarily be any need to revisit the data, it is indeed 'good enough'.

The Pareto theory or '80/20' rule is also an example of where incomplete is good enough. This rule observes that the majority (upper quartile) of an item would seem to be completed with a minority (lower quartile) of effort and has commercial implications. Is it worth expending "80%" effort to complete the last "20%" when the 'low hanging fruit' are not just available but also more profitable? The minority effort would seem to be 'good enough' to maintain a profitable business.

Overproduction and over-processing are two of Toyota's seven waste and support the idea that it is possible to do more than is needed. Not doing enough is not explicitly identified even though over-processing can also be interpreted as incorrect processing (Liker 2004). In a manufacturing process, not finishing a task is likely to be classed as a defect, resulting in scrap or rework. This results from a fundamental difference in work flow between construction and manufacturing. In construction the work force moves through a static product whereas in manufacturing the product moves through a static work force. Construction workers move in and out of the product and a practice of 'good enough' exists within project management, where

items of work are left either to be completed later or sometimes not at all. This approach is evidenced by the tacit acceptance of “snagging” or the “punch list” as a primary management tool to ensure work is completed to an acceptable standard. Brodetskaia *et al* (2010) also observe this tendency of trades to return to work and classify it as re-entrant flow. Kennley (2005) proposes payment mechanisms and incentives are set up to trigger payment for completion of the major items permitting subcontractors to focus on those major items delaying or even walking away from completion of the last, non-profitable, minor items of work. This is a very damaging to a project as it escalates the cost of the minor tasks required to finish the work. Although the case study operatives are directly employed, it is still standard behaviour to leave minor items either for someone else or to be picked up later.

Currently it is not clear whether this behaviour can be explained because:

- operatives simply start before preceding work is finished (making do),
- work is considered finished because it is ‘good enough’,
- there is a drive to start as much as possible in order to increase productivity,
- all of these, or
- something else

Ronen (1992 cited in Formoso *et al* 2011) certainly confirms an underlying assumption that overall productivity increases with high utilisation of resources that leads managers to start as much work as soon as possible as a method for increasing productivity. What is clear from this KTP is that site managers and operatives were not giving adequate consideration to whether or not the work could be finished, nor were they giving much consideration to the trades that preceded or followed. Work was completed to a standard that was ‘good enough’ and they were unaware of the consequences of doing this. They were lax in the planning of work and were also poor at monitoring the work to check if it was finished (as reported by the operatives). Further investigations revealed that site managers and site operatives across all trades did not share a common understanding of what constituted ‘finished’ work. This should not be confused with a lack of information (design or specification) or even poor communication but rather as an attitude or behaviour towards the required quantity and quality of work and what might be construed as ‘good enough’.

RESEARCH METHOD

The design and build organisation were committed to making improvements to all of their operations. The perceived making do attitude was a major concern and something that had to be addressed as part of their aim to embed a lean culture throughout the directly employed workforce. As part of the KTP a number of research methods were considered and discussed with the directors of the design and build organisation. The outcome of the discussions was to use a simple and cost effective research method that could identify the scale of the problem and also bring about improvements to ongoing projects within a short timeframe.

Given that the intention of the KTP was to actively and intentionally effect changes within the design and build organisation (the social system), applied research in the form of action research was the method chosen. Action research involves a planned intervention by a researcher into naturally occurring events (Lewin, 1946) and is a valuable variant of the quasi-experiment in management research (Gill and Johnson, 1989). The usual approach is to address the practical problems facing practitioners and also to contribute to knowledge about the social system being researched, which was consistent with the aim of the KTP.

Action research is conducted in distinct stages (Lewin, 1946). For this research project the stages were; problem identification; establishing a plan of action; implementing the plan of action; monitoring; and finally evaluation of the intervention.

PROBLEM IDENTIFICATION

In accordance with the philosophy of action research (Lewin, 1946) the researchers were actively involved in the problem identification stage. Data was collected via visual observation of work on the three construction sites. All three sites were social housing projects in the Greater London area. Although the projects were for different clients, they were all nearing the final stages of construction and therefore the majority of work was concerned with internal finishing. Given the stage of the projects a decision was taken to concentrate on three interdependent trades; carpentry, plumbing and decorating. Observations were supported by digital photographs and written notes describing the location and extent of unfinished work. The status of the work on site was checked against the master programme and weekly work plans, adapted from the Last Planner System[®] (Ballard 2000). Informal discussions were also held with operatives, trade foremen and site managers to gather perceptions and attitudes towards their work. The problem identification stage took approximately four months to complete, with a researcher visiting each construction site at least once a week for a minimum of half a day.

Observations

Visual observation of the workplace helped to identify a number of tasks that were not finished. For example, shelves in kitchen units were missing or not properly fitted; screw caps were not fitted; walls and ceilings were only partly mist coated with paint. Reluctance to finish work was seen to have a negative effect on the following trades, who often found that they could not complete their task because the previous trades had not completed theirs. For example, in a cylinder cupboard, it is very difficult for carpenters and decorators to undertake their tasks once the hot water cylinder is fitted. Therefore, as a common practice before a plumber fits the cylinder all carpentry and decoration works should be complete. However, it was frequently observed that these works were not entirely completed, but just sufficiently to allow plumbers to start (e.g. timber skirting fixed only behind the cylinder, cupboard partly decorated etc.) requiring carpenters and decorators to return to the cupboard to finish off their work later. .

Re-entrant flow (Brodetskaia *et al*, 2010) was commonly observed as a result of planning based on tasks, rather than on location and standard "batches". The work in the cylinder cupboard was a task that was programmed individually for each residential unit, and so the trades were encouraged to think only in terms of working in cylinder cupboards and then coming back to work on other tasks. Structuring work around locations and standard "batch" sizes that minimised unnecessary movement would enable carpenters to complete work in a unit before moving to the next batch. For example; fitting doors, architraves and skirting for the entire unit (batch) rather than just the back of the cylinder cupboard would reduce the incidence of re-entrant flow. Similarly, decorators could mist coat the entire unit along with decorating the cylinder cupboard. Instead the trades went from one unit to another and back again in what appeared to be a random manner. To compound the problem the operatives were reporting their tasks as 'finished' to their foremen, who then reported this to the site managers. At the time there was no process of checking whether the work was completed or not, and it was left to be picked up during snagging; which was usually just before the client's clerk of the works visited the site. The result was that the work was not being reported correctly nor recorded accurately on the weekly work plans,

which led to confusion regarding progress of the work. Tradesmen had to return to the same unit(s) again, with all their materials and tools, to finish a task. This was not only wasteful in terms of labour, but it also had the effect of raising costs and extending the time required to fully complete a task. Observations also found that it was not always the same individual who started the task that was appointed to complete it. This type of multi handling of tasks further contributed to process waste; and in some cases led to inconsistent quality of workmanship and additional time because a switch of operative also required a review of what had previously been done prior to completing the work.

A second example was observed in work to the windows. In this case security screens were to be fitted over the opening lights. The carpenter was ready to fit these but the windows had not been caulked externally. This triggered an operative to be engaged to prepare the windows for the waiting carpenter. To allow immediate access this operative sealed only the half of the window to which the screen was to be fitted. This would seem to be good enough to avoid a delay to the carpenter which was judged a more serious consequence than the operative having to return to finish the window. However, the operative then proceeded to caulk half of every window even though there was now time to complete each one as the carpenter's work was slower. This is an example of doing just enough work to permit a follow on trade to start. As such it is clearly an example of inappropriate processing and although all the inputs were available both for the caulking and the fitting of the screens, the caulking wasn't finished. It is proposed therefore that incomplete processing as a result of a 'good enough' is also a type of waste. If it causes incomplete inputs for subsequent tasks then it is a form of 'making-do'. However, it is possible the incomplete work does not result in incomplete inputs for subsequent tasks but causes waste as re-entrant flow as in this caulking example. A theoretical question arises here as to whether common understanding added as an eighth flow. If this was the case then a lack of common understanding would mean the 'good enough' behaviour observed would then become making do as defined by Koskela (2004)

Interviews

Informal discussions were conducted in an attempt to understand the root cause of the making do attitude. A total of 15 in depth discussions were conducted between the KTP associate and the site managers, trade foremen and site operatives on each of the three construction sites. The findings revealed a consistent pattern across different sites, with the inadequate reporting of work forming typical (expected) behaviour, essentially a culture of making do. None of the tradesmen interviewed seemed to appreciate why it was important that they finished their task in its entirety and tidy up to make ready for the next trade. Individuals were quick to adopt a defensive attitude and offer excuses for not finishing their task(s). They were of the opinion that the way in which they were working was common on all construction sites and was the correct way of working. None of those interviewed could see anything wrong in their behaviour. Indeed, they were not ready to accept there could be a better way of building. A few of their arguments included:

“It is not interrupting the work of any other trade...”

“We have always done it like this and I do not see any problem in this...”

“These things can be picked up while snagging, why bother now...”

An associated problem was that the site managers were accepting unfinished and/or substandard work because they did not have a clear or shared understanding of what constituted finished work. In effect they were condoning a making do attitude.

The problem

In summary, the challenges identified were:

- No common understanding of when a task was finished.
- Incomplete tasks were being reported and recorded as finished as the work was judged to be good enough
- There was no formal checking process to ensure tasks were executed to the required standard. Site managers were accepting the word of the operatives and trades foremen without checking to see if the task was complete as reported.
- There was a poor attitude towards learning, and
- There was a lack of incentives to address the 'making-do' culture.

IMPLEMENTING A PLAN OF ACTION

Once the data had been analysed to establish the extent of the problem a plan of action was discussed and agreed with the directors and some of the senior managers in the company. This was done to ensure that the proposed intervention was practical to apply to the ongoing projects and was also cost effective.

The number of times each trade has to visit a unit (could be a flat, a room or a floor) depends upon the sequence of work and handovers between two or more trades (Brodetskaia *et al*, 2010). It may be an obvious point; but the fewer visits made to a unit, the more efficient and cost effective the process. Similarly, smooth handovers from one trade to another (work completed, the area tidied up and made ready for the next trade to start work) also contributes to the efficient flow of work. The challenge was to address the problems identified above, which involved two steps:

- Step 1. Develop a common understanding
- Step 2. Use visual management techniques to reinforce the understanding

Step 1. Develop a common understanding

Prior to organising visual management techniques it was important to raise the awareness of site personnel to a number of issues:

- It is possible to improve the execution of internal finishing works and finish individual tasks
- Finishing tasks will reduce the number of times each trade has to access a given space, which will ultimately enhance performance
- It will also reduce multi handling of the work, which not only has negative cost implications but also has a detrimental effect on the quality.

As a part of the awareness initiative discussions were instigated by the KTP associate with site managers and trade foremen. These discussions further revealed that the trades did not follow any particular sequence of work, i.e. the work sequence was different for different units with the same specifications, even within the same building. Work sequences were defined purely on the basis of availability of space, resources and materials required to start a task. This resulted in chaotic working practices. Furthermore, because trades were not working according to a pre-defined work sequence it was very common for trades to damage the work already done by other trades; creating unnecessary repair work.

A number of solutions to this issue were discussed between the directors of the design and build organisation, the academic supervisors and the KTP associate. A decision was made to identify the best sequence of internal finishing works that

would be most suitable to a directly employed workforce (essentially a standardised work breakdown structure). The aim was to minimise the number of times each trade needed to access a unit, and also to allow each trade to finish all of their tasks before leaving the unit. The KTP associate worked with trades foremen, site managers and project managers to identify this best sequence – the ideal sequence for internal finishing. It was however pointed out that this sequence should have some flexibility to allow works to proceed differently for different types of buildings with different specifications. Working on ideal sequence was a part of the KTP project but it is outside the scope of work reported in this paper.

Step 2. Visual management

Visual tools are used extensively within lean organisations and are a proven means of effectively highlighting problems (e.g. Mann, 2010). Visual management makes it easy to understand any variance between expected and actual performance. It is based on the fact that humans are more attracted to what they see than to what they hear. Visual control tools are very transparent in reflecting true facts and are very simple to understand (Mann, 2010; Tezel *et al.*, 2010). A visual workplace helps workers to see when something varies from the agreed norm (Liker & Meier, 2006).

During the implementation stage two workshops were organised with the aim of highlighting the issues associated with unfinished work. Six decorators and 18 carpenters participated in the first workshop. A month later, six decorators, 20 carpenters, five plumbers and four site managers participated in the second workshop. The workshops employed a lean game called 'the lean wall' which is based on the principles of visual management (see for example, Mann, 2010). Photographs highlighting finished and unfinished work were used to communicate the message of what is finished and the standards expected by the directors of the company.

Workshop 1

During the monitoring period many digital photographs had been taken to document the extent of the finished and unfinished work. These photographs were reviewed by the researchers and the directors of the company. The purpose was to identify the photographs which best demonstrated the difference between finished and unfinished works. It was hoped that these photographs would also help to highlight the 'making do' attitude of the workforce. 24 photographs from three construction sites were selected and used in the workshop. The photographs displayed three stages of a number of different tasks:

- (i) work that was under progress,
- (ii) unfinished work, but just sufficiently completed for the next trade to start,
- (iii) work that was finished to the required standard.

The aim of this workshop was to help tradesmen understand when a task should be considered, and reported, as finished. Finished work is defined by the answer to the following question: 'Will the client accept this work as it is and pay for it, or will the client ask us to spend a few more hours to bring it to the required standard before accepting and paying for it?' The workshop was facilitated by the KTP associate and an academic supervisor to discuss unfinished work identified on four projects which were nearing completion.

At the workshop participants were divided into groups of five or six people. Each group represented a particular trade and was given a set of photographs that showed an example of work done by them. There were two rounds of assignments in this workshop. Both involved analysing and answering a question regarding the

photographs. Each group was asked to arrive at a common agreement for each of their photographs.

In round 1 the groups were asked to identify whether the task shown in the photograph was (a) still under progress or (b) ready for the next trade to start their job. Tasks shown in each of the photographs were given a reference number that related it to the task on the ideal work sequence, a copy of which had been provided to each group. Information regarding the next trade was available on this ideal work sequence. As all trades had already agreed to this ideal sequence in past at the time it was being prepared, there were no disagreements with regards to the task itself or with the task for the following trade.

If the group decided the task shown in the photograph was ready for the next trade they placed a green sticker on it. If they decided the photograph was taken while the task was still under progress, they were asked to place a red sticker on it. All groups were then asked to place the photographs on the lean wall, which was divided in two halves: one for the photographs with a green sticker; and the other for the photographs with a red sticker. This allowed participants to see and comment on the decisions made by the other groups. However, changing the colour of the sticker was not allowed once the photograph had been placed on the wall.

In round 2 the groups were asked to further analyse the photographs that were deemed ready for the next trade and tasked with the following question: 'Is the task shown in the photograph finished, irrespective of the next trade, so that the client will be happy to pay for it; or there is something missing which needs to be done to finish the task to the required standard and therefore the client will not want to pay for it?' Participants were once again asked to place green and red stickers on the photographs. Another green sticker indicated that the task was finished and the client should pay for it; a red sticker indicated that further work was required to finish the task to the required standard before handing it over to the client. Similar to round 1 these photographs were also displayed on the lean wall. This time the green half was further divided in two halves: one for the photographs with two green stickers; and other for the photographs with one green and one red sticker. Putting up these photographs on the wall opened up a discussion amongst participants regarding what was missing and why the task is incomplete or complete.

The workshop was successful in helping to highlight the difference between a finished task and a typical construction trade workers' understanding of what constituted a finished task. During round 2, when participants were analysing the photographs that showed a task that was ready for the next trade but not completed to its entirety, it was evident from their body language that they were learning to recognise what was 'finished' and what was not. At the conclusion of the workshop it was explained to all the participants how each time they accessed any space the company incurred additional costs of time and resources. Discussion then focused on the waste of resources brought about by unfinished work and the making do attitude. It was also explained that this impacted on the company's profit margin and subsequently the profit share of the employees (which included participants themselves).

Workshop 2

Building on the success of workshop 1, a second workshop was organised. This time the aim was to achieve a common understanding of what constituted finished work throughout the entire organisation. The second workshop was organised a month after the first and followed the same format using the visual management technique. This time a greater number of people participated, which was the result of

deliberately holding the workshop the same day as company's quarterly meeting. Employees were invited to participate and give feedback on how the firm's management could help the site operatives to eliminate the making do attitude.

The majority of the trade foremen suggested that because they now had a common understanding of what was finished, the making do attitude could be significantly reduced. This could be linked to continual monitoring of progress. It was therefore agreed that the site managers would walk around the construction site twice a day and with trades foremen at least once a week to ensure that all tasks are being executed correctly and finished to the required standards.

MONITORING AND EVALUATION

Monitoring of work by the KTP associate continued for two months after the completion of workshop 2. This took place on two new sites, with the same site personnel. Data was then analysed to establish the impact of the intervention and to see if there had been any improvements. The researcher visited the sites at least once a week for a minimum of half a day to observe and document the work, which was consistent with the earlier monitoring period.

During the initial stages of internal finishing works the trades were demonstrating significant improvements. Tasks were being finished to the correct standard at the first time. However, as the number of workers on the site increased, the pressure to hand the space over to the next trade increased. As a result the operatives started to drift back to what they were doing in the past (i.e. making do). This shift could also have been influenced by a period of inclement weather during which most of the tasks on the weekly work plans were not completed, and hence there was increased pressure to complete tasks. The bad weather disrupted the planned flow of work, which resulted in some overlap and rescheduling of tasks. This emphasises the challenge of building in the winter in the UK, where it is difficult to maintain a consistent flow of work despite everybody's best intentions.

However, despite this temporary drift back towards a 'making-do' attitude, a positive change was observed on the construction sites. If a task was not completed in its entirety, for whatever reasons, the operatives and foremen no longer reported it as finished, but highlighted it as not finished. In one or two instances it was observed that the trades foremen did attempt to report tasks that were not finished, but the site managers refused to accept the work. This led to increased certainty of work flow and increased productivity.

As part of the evaluation process site managers were asked to record the reasons why tradesmen were unable to finish their tasks. Data was analysed after a period of two months when a considerable amount had been collected. Analysis revealed that the three most frequently occurring reasons for tradesmen not being able to finish their tasks were:

- lack of materials, or the materials delivered were not fit for purpose;
- clash of space between two or more trades;
- lack of appropriate human resources for the task.

This helped to highlight the need for better planning and management of work. It was subsequently addressed as part of the KTP project, but it is outside the scope of the work reported in this paper.

DISCUSSION

At the outset of the research intervention the making do attitude was present across a number of levels within the organisation. The extent to which it was prevalent was only revealed through the observations made on live construction projects. This is where the value of a KTP associate was demonstrated. Employed by the university partner, but being located within the organisation, allowed the KTP associate to spend considerable amounts of time on the sites and observe normal working practices. Because of the length of time the KTP associate spent with the site personnel he became an accepted and trusted member of the organisation. This meant that the site personnel appeared to be happy discussing their work with the KTP associate and they were also relaxed about having their work photographed.

The use of workshops and simple visual management techniques helped to engage the workforce with the issues, raising awareness and contributing to a change in the attitude and behaviour. The principles associated with visual management were adapted for use in the awareness development workshops, combining feedback on work done with peer assessment of that work. The images used were directly from the workshop participants' experience, which gave the images both relevance and impact, contributing significantly to the development of a shared understanding of what was, and was not, required. At this stage of the KTP project there was no attempt to extend this learning into the creation of a visual workplace by developing visual control systems. Instead, a 'best work sequence' was established, and although visualisation was an underpinning technique in developing understanding, it fell short of the definition of 'standard work' and prevented the visual training aids from being developed as management tools for the organisation.

One criticism of the intervention could be that in giving attention to these work packages the performance of the workers would increase because of the psychological stimulus of being singled out in the experiment; known as the Hawthorne effect. So whatever the intervention - be it applying lean thinking or not - improvements in performance are to be expected. There is, however, evidence to suggest that the improved performance was not just a result of the Hawthorne effect. There were dips in performance during the research period, despite the attention from the researchers, which would tend to suggest that the action research was not viewed as anything different to usual work by the individuals.

CONCLUSION

The aim of the research was to try to improve the attitude of the trades people, trades foremen and site managers towards completing their work packages so that the work flow could be improved. Not finishing work in this way was defined as 'good enough' behaviour and proposed as an expansion of the definition of making-do. The interventions were successful, helping to facilitate the better flow of work on the construction site and hence help to reduce process waste. However, as discussed above, the intervention has not resolved the challenge of making do in its entirety. The habits of the workers and managers are deeply ingrained and constant effort is required to keep all site personnel engaged with the drive for more efficient working. The concern is that once the KTP project is complete and the KTP associate is no longer present on the sites, then the behaviour may revert back to a making do attitude. Here the role of the site manager in reinforcing a lean thinking culture will be particularly important.

Implications for contractors

In terms of the general applicability of the findings to other construction organisations several issues were demonstrated in regard to addressing unfinished work. Additionally, the use of visual stimuli was effective, quick and relatively simple to implement. However, there was a decline in the duration of the effect, which needs to be noted and addressed in future interventions. It was clear to the researchers that visual images cannot be used effectively in isolation and there needs to be effective leadership and support in place to help individuals to maintain their performance.

Implications for theory

A perceived shortfall in the original list of seven activity wastes observed within Toyota (Womack & Jones, 2003; Liker, 2004) was evident; where the managers' emphasis was on starting the work, rather than finishing it. This is a form of under-processing, in which a proportion of activities in a work task are not performed at the first opportunity, which when resulting from incomplete inputs, Koskela (2004) termed 'making do'. However, it has been observed that not all under-processing results from, or causes, incomplete inputs and so they do not fall under Koskela's definition. A behavioural phenomenon of processing to a state that was deemed 'good enough' has been observed and this can be related to the waste of unevenness in production levels which identifies variation from the standard process as wasteful regardless of whether the variation is higher or lower (Liker, 2004). Waste was being caused because there was no common understanding of what the work looked like when it was completely finished, thus the operatives simply did what they thought was enough and moved onto another unit. However, if an eighth flow of 'common understanding' was added to Bertelsen et al's (2004) seven flows, then not finishing work in the way it has been observed would fall clearly into Koskela's (2004) definition of making-do. The implications for construction management are that failure to specify proper work standards and a lack of common understanding of what is required make it difficult to address unevenness in production

Further research is needed to better understand the implication of unevenness of demand and how it effects both operations and processes in construction projects. From this a new understanding of the barriers and drivers to standard work may be developed to assist construction reliability, an important consideration for contractors and clients alike. A theoretical question arises

REFERENCES

Alarcon, L. F., & Calderon, R. (2003) *Implementing Lean Production Strategies in Construction Companies*, Honolulu, Hawaii, USA.

Ballard, G. (2000) *The Last Planner System of Production Control*, PhD Thesis, The University of Birmingham.

Bertelsen, S., Henrich, G., Koskela, L. and Rooke, J. (2007) Construction Physics, in *Proceedings of the 15th Conference of the International Group for Lean Construction*, Michigan, USA.

Brodetskaia, I., Sacks, R. and Shapira, A., (2010) Implementation of pull control in finishing works with re-entrant flow, in *Proceedings of the 18th Conference of the international Group for Lean Construction*, Haifa, Israel.

Gill, J. and Johnson, P. (1997), *Research Methods for Managers, Second edition*. Paul Chapman, London.

Formoso C. T., Sommer, L. Koskela, L. J. & Isatto, E. L. (2011) An Exploratory Study on the Measurement and Analysis of Making-Do in Construction Sites in *Proceedings of the 19th Annual Conference of the International Group for Lean Construction*, Lima, Peru. p236 – 246.

Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. PhD Thesis, University of Technology, Espoo-Finland.

Koskela, L. (2004), Making Do – The Eight Category of Waste, in *Proceedings of 12th International Group for Lean Construction*, Elsinore, Denmark.

Mann, D. (2010), *Creating a Lean Culture: tools to sustain lean conversions*, (Second edition), Productivity Press, New York.

Lewin, K. (1946) Action research and minority problems, *Journal of Social Issues*, 2, pp 34-36.

Liker, J.K. (2004) *The Toyota Way*, McGraw-Hill.

Liker, J.K. and Meier, D. (2006) *The Toyota Way Fieldbook*, McGraw-Hill.

Ohno, T. (1988), *Toyota Production System, Beyond Large-Scale Production*, Productivity Press, Cambridge, MA.

Ronen, B. (1992). "The Complete Kit Concept." *International Journal of Production Research*, 30(10), 2457-2466.

Serlin, R. C.& Lapsley, D. K. (1985) Rationality in psychological research: The good-enough principle. *American Psychologist*, Vol 40(1), 73-83.

Serlin, R. C. & Lapsley, D. K. (1993) Rational Appraisal of Psychological Research and the Good Enough Principle in *A Handbook for Data Analysis in the Behavioural Sciences : Methodological Issues* by Kerer. G & Lewis. C. Routledge, London. P199 – 228.

Tezel, A., Koskela, L. and Tzortzopoulos, P. (2010), Visual Management in Construction – A Study Report on Brazilian Cases, *SCRI Research Report*, University of Salford, UK.

Womack, J. and Jones, D. (2003) *Lean Thinking*, Free Press, New York.