LESSONS LEARNED PRACTICES: CASE STUDY OF A LEADING IRISH CONSTRUCTION ORGANIZATION

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The implementation of lessons learned (LL) practices within construction organizations are viewed as an important part of knowledge management (KM), having the potential to improve the outcomes of a project. PJ Hegarty & Sons, a leading Irish construction organization, has recently implemented such practices as part of the Engineers Ireland Continuing Professional Development (CPD) accreditation scheme. The purpose of this paper is to identify and evaluate the adopted practices, which include a LL database, supported by LL seminars. Adopting a case study methodology, a survey and in-depth interviews with a broad spectrum of management and professional staff was conducted, including a director, project managers, quantity surveyors, foremen and engineers. It was found that the delivery of LL requires careful consideration of its intended users. In addition to integrating LL practices into existing organizational procedures, notification of new lessons and continuous training on the use of the database are required. Delivery of LL seminars should be focused at project-level and conducted on site to support both individual and organizational learning. The use of both technology and face-to-face interaction is important in the success of LL, particularly in aligning individual learning with that of the organization.

Keywords: case study, construction organization, continuing professional development, knowledge management, lessons learned.

INTRODUCTION

The construction industry is facing numerous challenges; increasing competition, globalization of the construction market, increased demands from clients and society, the impact of new technology, and the requirement to maintain a highly skilled workforce at all levels (Egbu and Robinson 2005). Indeed as a highly knowledge-intensive industry, with specialized expert knowledge and problem solving know-how to the fore, the industry requires a more structured approach to managing knowledge (Egbu and Robinson 2005). Knowledge management (KM) has been promoted as a means of harnessing and utilizing intellectual resources to address these challenges, yet there remains uncertainty about how to devise and implement a viable and cost effective KM initiative in practice (Kamara *et al*. 2002). Embracing the information systems and human resource management strands of discourse, KM is defined from an integrated perspective by Jashapara (2004: 12) as: “the effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organization’s intellectual capital and performance.” However, due to its project-based, fragmented and unstable nature, the construction industry is recognized as

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being poor at learning on a consistent basis and improving performance and is notoriously slow in adapting to progressive change (Orange *et al*. 2003). It is now recognized that there may be much greater potential for KM within individual companies as opposed to temporary project teams (KLICON 1999).

Lessons learned (LL) practices are an important aspect of KM. LL practices refer to "the activities, people and products that support the recording, collection and dissemination of lessons learned in organizations" (Snider *et al*. 2002: 291). The purpose of LL is to capture experiences, successful or otherwise, allowing an organization to avoid repeating costly mistakes, improve future performance and ultimately, the contractor's profit (Carrillo 2005; Kartam 1996). In a study of American contractors, Fisher *et al*. (1998) identified a number of other reasons for implementing a formal LL process as: high staff turnover leading to loss of experience; large size of organizations make sharing knowledge difficult; and departmental silos and fragmentation within the organization. Two key issues were identified by Kartam (1996) in the development of LL practices, a manageable format for organizing, storing, retrieving and updating information and an effective mechanism for collecting, verifying, categorizing and storing information. In devising such practices, Robinson *et al*. (2005) identify two distinct strategies: codification and personalization. Codification involves capturing knowledge in an explicit form and leveraging it using IT tools such as a LL database (LLDB). Personalization focuses on sharing tacit knowledge through human interaction. While a combination of both codification and personalization is most appropriate (Kamara *et al*. 2002; Fisher *et al*. 1998; Voit and Drury 2006), there has been a scarcity of solutions about how to effectively marry social processes with technology (Dixon 2004).

Based on the accepted potential for KM within a construction organization, the objective of the reported research is to identify and evaluate LL practices within a leading Irish construction organization through a case study methodology with the aim of identifying LL practices can be improved.

THE LESSONS LEARNED PROCESS

Fisher *et al*. (1998) developed a LL process comprising the following three stages.

Collection

The identification and capture of a LL is an extremely difficult process, with a variety of tools identified such as post-project reviews and debriefing (Disterer 2002; Kartam 1996). Two approaches have been identified for collection of LL; "a 'sought input' type collection process, where a custodian of the LLP obtains input from various agencies" (Fisher *et al*. 1998: 45) and a requirement for individuals to submit LL themselves (Kartam 1996).

Analysis

A LL must be significant in that it will have a real impact, valid in that it is factually and technically correct and applicable in that it identifies something that eliminates the potential for future failures or reinforces a positive result (Weber and Aha 2002). The analysis of contributed LL is vital considering that "construction practitioners will not accept an assertion that a certain method is superior to another, without a sound rationale" (Kartam 1996: 19). Fisher *et al*. (1998) recommend that analysis of LL be carried out by a team of senior staff with extensive industry experience. In documenting a LL, Kartam (1996) identifies three key components required, a title

describing the lesson, information regarding the source and context from which the lessons is collected, and a means for sufficiently classifying the lesson in a manner that allows fast, clear retrieval by multiple parameters.

Implementation

The dissemination of LL can occur by two methods, push and pull. Push methods deliver the LL directly to the user based on their role, interests, training and experience, while pull methods leave the burden of search to the user, who must devote their attention to the source (Weber and Aha 2002). In this context, Weber and Aha (2002: 292) discuss the distribution gap which refers to "the difficulty of transmitting lessons between a lessons learned repository and its prospective user." This can occur for a number of reasons: distribution is not part of organizational processes, users may not know or be reminded of the repository, users may not have the time or skill to retrieve and interpret textual lessons, and subsequently apply the lessons successfully (Weber and Aha 2002). A study by Fong and Yip (2006) identified e-mail or written documents as the most suitable distribution channels for lessons to construction professionals, intranets or websites being the least suitable.

IMPLEMENTING LL PRACTICES

In attempting to implement LL practices and indeed other KM initiatives, a number of challenges have been identified (see Table 1 for LL specific challenges), including poor organizational culture, lack of top management support, lack of dedicated resources such as staff, time and money, and poor ICT infrastructure (Fisher *et al*. 1998; Snider *et al*. 2002; Kartam 1996; Carrillo 2005; Weber and Aha 2002).

Table 1: Challenges in adopting LL practices in construction

Lack of time to capture and use learning experiences
Usually captured at the end of the project when many people have moved on
Loss of insight due to lime lapse between lesson and recording
Failure to uniformly document LL in a useful manner
Lack of proper classification system
Difficulty integrating with existing operations and procedures
Difficulty sharing lessons between experienced and inexperienced individuals
No motivation or perceived benefits for individual employees
Failure to deliver lessons when and where they are needed
Requires people to internalize LL and apply them at work
Difficult to measure and communicate benefits

To improve LL practices, Davidson (2006) advises that the lessons should be regularly reviewed to ensure accuracy, reliability and relevance, incorporate appropriate LL into business processes, training and checklists, educating people to use the LLDB, demonstrate the value in sharing LL and provide positive feedback to contributors and users. Voit and Drury (2006) identify two key aspects of LL programs as influencing program effectiveness, information usefulness and human intermediary activities. Information usefulness is the perceived usefulness of the lesson learned, particularly in relation to an individual's current job responsibilities. To reinforce the importance of the LL program, human intermediaries (e.g. managers) should monitor and review their staff's use of the LL. In order to create an environment conducive to learning, senior management need to visibly support an LL initiative, assess the organization's culture, eliminate barriers, set goals, get departmental buy-in, designate a champion, empower workers, allocate resources, and measure and track results (Robinson *et al*. 2005; Fisher *et al*. 1998).

LINKING LL TO CPD

A central problem of promoting learning across an organization is that despite people acting collectively, they actually learn individually (Kleiner and Roth 1997). Terrell (2000) contends that far from being learned, lessons are at best, observed, particularly in project-based organizations who have found it extremely difficult to capture and reuse the LL (Dixon 2004). In order to move beyond this, Dixon (2004: 18) believes that LL need to be connected to social processes, "the development of relationships, reflective conversations, probing questions and in-depth interactions – that are the backbone of knowledge sharing." In an attempt to address this issue, Turner Construction has devised a knowledge network to develop and train individual employees, aligning learning with the overall business strategy, improving both individual and organizational performance. Adopting a blended learning approach, Turner utilizes its own experiences and knowledge to develop both face-to-face and web-based CPD courses for its staff (Lemons 2005). Training is viewed as an important part of LL practices, in promoting the use and benefits of LL practices and incorporating actual LL into training (Fisher *et al*. 1998; Fong and Yip 2006).

THE IRISH CONSTRUCTION INDUSTRY

Considered "the most important part of Irish economic growth", the overall output of the industry in 2006 was €36bn, accounting for 24% of the country's GNP, with over 12% of the country's workforce directly employed (Davis Langdon PKS 2006: 3). The industry is however, facing a number of challenges: the introduction of fixed price government contracts, an increase in the number of foreign-based firms entering the market, over-reliance on the housing market and a predicted slowdown in construction output in the coming years (DKM 2006). Documented low levels of R&D and innovation in this important industry need to be addressed through improved knowledge transfer and creative thinking (Kelly 2005; CIF 2004). In this regard, the Forum for the Construction Industry, Engineers Ireland and the Construction Information Technology Alliance (CITA) have all cited the strategic importance of KM and its contribution to the knowledge economy.

ENGINEERS IRELAND

Ireland's largest professional body Engineers Ireland (EI) have introduced a CPD accreditation scheme for employers of engineers across a spectrum of industries. Twelve of the top twenty Irish construction companies are currently engaged in the accreditation process, of which three are fully accredited. Specifically defined criteria have been established, against which accreditation of companies is considered: CPD policy, performance management system, CPD activity, recording of CPD, mentoring, involvement with professional institutions, KM system and management control system. It is reasonable to suggest therefore that CPD has an important role to play in KM within construction, at individual, project and organizational levels.

RESEARCH METHODOLOGY

A case study methodology was adopted to evaluate LL practices within PJ Hegarty & Sons (PJH), a leading Irish construction organization. Such an approach was chosen as it seeks a range of different kinds of evidence in a case setting, which when abstracted and collated has the potential to provide the best possible range of answers (Gillham 2000). This study forms part of a wider research project investigating KM in the

leading 20 Irish construction organizations as they are perceived to exert the most influence on the approach to managing construction projects and the industry in general (Thomas 1999). Following an interview with a director from PJH in January 2006, the possibility of conducting some in-depth research emerged leading to the design of a questionnaire. Administered between February and April 2006, the purpose of the questionnaire was to explore the effectiveness of identified KM initiatives such as the LL database and seminars, CPD, and communications within the company's Dublin office. Follow-up interviews were then conducted with the full site team on a €70m design and build, commercial development project based in Waterford between May and June 2006.

CASE STUDY RESULTS AND ANALYSIS

Founded in 1925, PJH had a turnover of €320 million in 2006, making them the sixth largest Irish contracting company. Employing in excess of 700 staff, the company undertake a range of large construction projects throughout Ireland from offices located in Dublin, Cork, Limerick and Galway. In 2004, PJH became the first construction company in Ireland to be awarded EI accreditation for CPD.

The questionnaire was distributed to 180 professional and management staff via email, achieving a 36% response rate. As can be seen in Table 2, the survey respondents have a range of experience of working in the construction industry, with over a third having less than five years experience. Conversely, 69% of the respondents have been working with PJH for less than five years. Notwithstanding the 37% with less than five years' industry experience (mostly recent graduates), this may be due to the highly competitive nature of the industry at present, presenting considerable work opportunities to the industry's workforce. Coupled with a relatively young workforce (63% are 35 or under), this low level of experience within the company highlights the need for effective LL practices to improve both the individuals and the organizations knowledge base. The follow-up interviews were conducted with 13 staff members, comprising a senior contracts manager, a project manager, three quantity surveyors, three engineers, four foremen and the site safety advisor all based on site in Waterford.

Table 2: Survey respondents' industry experience

	< 5 years	**5–10 years**	**11–20 years**	**>20 years**	**Total**
Working in construction	37%	25%	14%	24%	100%
Working for PJH	69%	21%	8%	2%	100%

Overview of lesson learned practices

Based on the initial interview with a director, it was found that PJH had implemented LL practices as part of the KM requirement for CPD accreditation, comprising a LL database (LLDB) and LL seminars. The LLDB is managed by the company's quality and administration manager on a part-time basis. Based in the Dublin office, the LLDB administrator has over 30 years' experience in the construction industry, nine of which have been spent with PJH and is responsible for providing training on the LLDB when new recruits join the company.

The lessons learned process

- *Collection*: chaired by a director, PJH conduct a post-project review for all projects where key members of the project team discuss the best and worst experiences. The loss of experience due to time lapse is addressed by interim review meetings which are held every 6 months and "these would be reviewed

as part of the end meeting…it's really at the end of the job that you look back and say 'what are the big issues here?' I mean you can't log everything, if you catch the big issues, you're doing well." In this regard, he added: "at the end of the day our business is building, where do you stop with these initiatives…we try to do our best with the LL, but there's only so much you can do."

- *Analysis*: following the review, the key LL are documented by the contracts manager in a standard template detailing the title, description of the LL and contact details for individuals involved, and is classified based on the trade/subcontract package with which it is associated. Once completed, it is sent to the administrator, and if acceptable it is posted on the database, if not it may be sent back to the source for further clarification or edited by the administrator himself.
- *Implementation*: the archived LL are disseminated via two methods, pull methods occur in the form of a LL database (LLDB), a central repository that can be accessed from all offices and sites by logging into the company's network, the use of which is not measured and tracked by management. The company director acknowledges that "you are depending on people to take the time to look at the database. We also give seminars based on lessons learned on a fairly regular basis to support the database." In conjunction with the HR department, the LL administrator organizes LL seminars based on a selected trade or subcontract packages for staff, and on some occasions delivers them himself. These seminars are usually delivered in the training room of the Dublin office in the evening time.

Evaluation of lessons learned practices

Lessons learned database

According to the director, *"the theory is, and I'd be interested in the answer from your survey on this one, is that before you start a particular package you log onto the database and have a look, in the hope that you don't make the same mistake again."*

Table 3: Frequency of use of LLDB

Rank	Use of LLDB	%
1	Very rarely	34
2	When I have a specific query/problem	27
3	Never	15
4	Quite often	13
5	When a new subcontract package starts	11

Despite nearly three-quarters of the survey respondents (74%) stating that they found it beneficial to them in their work, Table 3 shows that *very rarely* ranked highest in terms of usage, with *when a new subcontract package starts* ranking lowest at 11%. During the interviews, the use of the LLDB was discussed, the following being the most pertinent issues identified:

- *Lack of time*: many respondents stated that they just didn't have the time to look through the database every time a new package started. "I haven't checked it in about a year…you don't get time to, unless you're sitting here twiddling your thumbs…it's extremely difficult when you're out on site all day."
- *Relevance to current role*: some people questioned the actual relevance of LL to them in their current position. One respondent stated "a lot of the things on

the lessons learned are relevant to foreman…they're the guys out there dealing with those issues…that's where the breakdown is, the people who really need to know don't have access to a computer, its not in their job description."

- *No requirement to contribute*: many people stated that there was no requirement on them to contribute to the LLDB, and as a result, didn't bother. One individual suggested "perhaps contributing to the lessons learned should be part of your work. The company I worked for in England did that, when you did your monthly report for the directors, you had to do your lessons learned."
- *Difficulty finding the most recent lessons*: the lessons are not categorized by date, "you have to sift through the older lessons as well." Indeed, 42% of the survey respondents ranked this issue as the most problematic factor in using the database.

In considering how to improve the use of the LLDB, a number of the interviewees contended that there should be refresher courses run, as most people felt that being shown how to use the LLDB on their first day with the company was not effective.

Lessons learned seminars

The LL seminars provided by PJH can count towards CPD hours with a variety of professional bodies, offering incentive for staff to attend. The survey found that 8% of respondents don't attend any seminars, 53% attend between 1 and 4, 31% attend between 5 and 9, with 8% attending 10 or more seminars each year. A number of problems with the seminars were identified in the interviews as:

- *Timing and location of seminars*: the seminars are run in the evening in the Dublin office, after a "hard day's work on site." Many of the interviewees cited fatigue and long travelling times as being counter-productive to getting any value out of the seminars. "We were out working in the rain one day, a big concrete pour…and then I'm into this thing at 5.30…and I mean the heat and all, I'd been out in the fresh air all day, out in the wind, and I come into this nice, cosy, comfortable room to a guy in a shirt and tie…and I'm gone!" One interviewee suggested that "there should be more done on-site, particularly on a big site like this where you have a lot of staff…it's not a thing that has to happen in head office."
- *Delivery of seminars*: "the likes of the office people would be giving a seminar on lessons learned…they talk about them, but because they're not involved on site, they don't come up with any solutions."
- *Relevance*: it is important that seminars are pitched at the right level to the audience "if it's not relevant or you know it already, you're going to switch off," a recurring theme in the interviews, people cited this aspect as putting them off attending again.
- *Experience of attendees*: a graduate engineer felt that they didn't gain a lot from seminars covering issues they hadn't yet encountered on site "once you've seen it been done, I find it's easier to go to a seminar and talk about it…it's hard to visualize something that you've never seen or experienced when you go into a room and listen to someone talk about it for an hour."

DISCUSSION

Based on a case study of LL practices within PJH, this section aims to highlight the strengths and weaknesses of their approach to LL with a view to identifying how construction companies can improve such practices.

The lessons learned process

- *Collection*: a *sought input* collection process is used, whereby the director responsible for the project in question facilitates a post-project review. This end of project review is augmented by interim review meetings during the course of the project and aims to capture the *big issues* related to the project.
- *Analysis*: the LL is analysed and documented on a standard template by the contracts manager, before being sent to the LLDB administrator for further analysis. The documentation of the LL appears to meet Kartam's (1996) recommendations for a title, contextual information and classification, although perhaps the LL should be review by a wider group prior to acceptance as recommended by Fisher *et al*. (1998).
- *Implementation*: both push and pull methods are utilized by PJH in disseminating LL, through seminars and a database respectively.

The process adopted by PJH focuses on capturing the main LL from each of their projects, as the director indicated that it would be difficult to capture all LL from a project. In order to improve this process and capture more LL, further integration with existing organizational practices is required.

Lessons learned database

The use of the LLDB is not monitored by company management, nor are staff required to use it as part of their work, leading to a distribution gap between the database and prospective users. Site-based staff do not dedicate time to using the LLDB as they view their work as being out on site, not at a computer, yet it is precisely these people who should be using it. Finding the most recent LL's were difficult as they were not categorized by date; a more robust classification and search functionality may address this. A simple email system notifying staff in relevant positions of new LL could potentially improve the dissemination of LL. Incorporating the use of the LLDB into company policy, linking use to subcontract awards, and requiring certain key project members to contribute a LL with their monthly reports could improve both collection and implementation of the LLDB.

Lessons learned seminars

To improve the dissemination of LL, CPD seminars are organized in the company office for staff to attend after work. The timing and location of these was found to be problematic for staff who had to travel to the office from site. Furthermore, the people who delivered the seminars were not necessarily those who had actually experienced the lessons learned, thus limiting their knowledge of the context within which the lesson originated. This highlights the problems of actually learning from a documented LL as discussed by Terrell (2000). The experience of people attending the seminars and the relevance of the LL to their work were other issues highlighted as being important. To improve the effectiveness of the seminars, they could be delivered on site to the project team as and when they are relevant. For example, conduct an LL seminar on glazing a week before the glazing subcontractor begins on site with all members of the project team, including foremen.

Linking lessons learned to CPD

The linking of the LL seminars to individual CPD appears to be a step in the right direction, the role of human intermediaries in reinforcing the importance of LL, vital. Collaboration between contracts managers, the HR department and the LLDB administrator, in the delivery of on-site LL seminars as part of CPD activities is required. Further integration of the LLDB and the LL seminars into a blended learning programme may enhance the effectiveness of delivering LL within the organization. In addition, there is now a need for the company to implement a system to track and measure the use and effectiveness of these practices and to communicate benefits throughout the organization.

CONCLUSIONS

The LL practices of a leading Irish construction organization have been identified and evaluated, with a view to making recommendations for other firms considering implementing LL. These practices were investigated in relation to the process used to collect, analyse and implement LL, exploring implementation through a LLDB and LL seminars. Based on this investigation, the following conclusions can be made:

1. Carefully design the LL process and integrate it into existing organizational procedures. The *collection* of LL should incorporate both a sought input and a requirement for individual contributions. Submitted LL should be *analysed* by a number of people, be consistent in their structure and classified by a number of parameters, particularly roles to which the LL is relevant. *Implementation* of LL should combine both push and pull methods, targeting specific staff members through direct distribution.
2. Use of a lessons learned database should be incorporated into existing organizational practices with careful consideration given to the classification system used, particularly based on date of LL. Emails and memos notifying staff of new LL and reminding them to use the database, in addition to refresher courses on the use of the LLDB are also recommended.
3. LL seminars should be organized for staff to augment the LLDB, with careful thought given to the timing, location and delivery of them. Site-based seminars may be more appropriate and relevant on large projects, which can be linked to current and upcoming subcontract and trade packages on site.
4. The integration of LL practices with CPD has the potential to align both individual and organizational objectives. The development of a blended learning approach to delivering and promoting LL merits further investigation, particularly in addressing the need for site-based CPD activities.

While LL practices have the potential to improve the performance of construction organizations, there has been little documented evidence of such improvements in practice. This paper has identified and evaluated LL practices within a leading Irish construction organization, highlighting a number of issues in relation to its implementation that may well be of benefit to other construction organizations in Ireland and overseas.

REFERENCES

Carrillo, P (2005) Lessons learned practices in the engineering, procurement and construction sector. *Engineering, Construction and Architectural Management*, **12**(3), 236–50.

Construction Industry Federation (2004) Construction Industry Federation website: http://www.cif.ie (accessed May 2005).

Davidson, J (2006) Finding the value in lessons learned. *KM Review*, **9**(3), 6–7.

Davis Langdon, PKS (2006) *Irish Construction Annual Review 2006*. Available online: http://www.dlpks.ie

Dixon, N M (2004) Does Your Organization Have An Asking Problem? *KM Review*, 7(2), 18–23.

DKM (2006) *Review of the Construction Industry 2005 and Outlook 2006–2008*. Dublin: DKM Economic Consultants.

Egbu, C and Robinson, H (2005) Construction as a Knowledge-Based Industry. *In:* C Anumba, C Egbu and P Carrillo (Eds.) *Knowledge Management in Construction*. Oxford: Blackwell Publishing.

Fisher, D, Deshpande, S and Livingston, J (1998) *Modelling the Lessons Learned Process: A Report to the Construction Industry Institute*, The University of New Mexico, Albuquerque, New Mexico, Research Report 123-11, January.

Fong, P S W and Yip, J C H (2006) An Investigative Study of the Application of Lessons Learned Systems in Construction Projects. *Journal for Education in the Built Environment*, **1**(2), 27–38.

Gillham, B (2000) *Case Study Research Methods*. London: Continuum Books.

Jashapara, A (2004) *Knowledge Management: An Integrated Approach*. London: Prentice Hall.

Kamara, J M, Augenbroe, G, Anumba, C J and Carrillo, P M (2002) Knowledge management in the architecture, engineering and construction industry. *Construction Innovation*, **2**(1), 53–67.

Kartam, N A (1996) Making Effective Use of Construction Lessons Learned in Project Life Cycle. *Journal of Construction Engineering and Management*, **122**(1), 14–21.

Kelly, K (2005) Innovation in the Building Industry. *The Engineers Journal: Journal of the Institution of Engineers of Ireland*, **59**(2), 83–5.

Kleiner, A and Roth, G (1997) How to Make Experience Your Company's Best Teacher. *Harvard Business Review*, **75**(5), 172–7.

KLICON (1999) *The Role Of Information Technology In Knowledge Management Within The Construction Industry*, Project Report of Knowledge Learning in Construction Group at the Centre for Research in the Management of Projects, University of Manchester Institute of Science and Technology.

Lemons, D (2005) Integrating KM and Learning at Turner. *KM Review*, **8**(2), 20–4.

Orange, G, Onions, P, Burke, A and Colledge, B (2003) *Knowledge Management: Facilitating Organisational Learning within the Construction Industry*, Discussion Paper, School of Information Management, Leeds Metropolitan University.

Robinson, H, Carrillo, P, Anumba, C and Al-Ghassani, A (2005) Knowledge management practices in large construction organisations. *Engineering, Construction and Architectural Management*, **12**(5), 431–45.

Snider, K (2002) Considerations in acquisition lessons-learned system design – Lesson Learned. *Acquisition Review Quarterly*, winter.

Thomas, K (1999) *The Influence of the Leading Firms on the Exploitation of IT in the Irish Construction Industry*, unpublished paper, presented at conference: Potential of Information Technology in the Construction Industry, 19 November, Dublin Institute of Technology.

Voit, J R and Drury, C G (2006) Supporting Vicarious Learning With Collaborative Lessons Learned Programs. *IEEE Transactions on Systems, Man and Cybernetics*, **36**(6), 1054–62.

Weber, R O and Aha, D W (2002) Intelligent delivery of military lessons learned. *Decision Support Systems*, **34**(3), 287–304.