

REVIEW OF CONSTRUCTION SAFETY RESEARCH METHODS: INTEGRATING THEORY AND PRACTICE

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This paper reviewed the research methods used by the construction safety articles published in the five high-ranked international journals and the CIB W99 international conference proceedings in, 2009. In total, 561 papers were published by these journals and proceedings, in which 88 are related to construction safety. These 88 papers were classified according to the research methods adopted. It was found that nearly half the papers (43.2%) used quantitative methods while about a quarter (23.9%) applied qualitative methods and very few (9.1%) adopted mixed methods research while the rest used other forms of research methods. The shortcomings of the research methods currently adopted are discussed together with the possible reasons of minimum impact of these research outcomes on construction safety management practice. After describing the nature of construction safety practices which includes safety knowledge development and safety learning processes, a mixed methods research which integrates the realms of theory and practice is proposed for conducting construction safety research. It is suggested that researchers should find opportunities to collaborate with practitioners in conducting construction safety research to ensure the relevancy and application of research findings such that to improve both safety management practices and theory development.

Keywords: construction safety, mixed methods, qualitative, quantitative, research methods.

INTRODUCTION AND RESEARCH AIMS

Despite its significant contribution to the global and national economies, the construction industry is unfortunately notorious as being one of the most dangerous industries (Australia Safety and Compensation Council [ASCC], 2010; Lingard and Rowlinson, 2005; Murie, 2007). It accounts for 7% of the world's employment, but 30-40% of the world's fatal injuries (Murie, 2007). The high rates of accidents and fatalities in the construction industry have caused much pain and suffering and financial losses of up to A\$1.6 million per accident (Sun and Zou, 2010). This indicates that substantial financial savings can be achieved from effective safety management. A study showcased that construction safety risk prevention and reduction programme can yield as much as 46% of return on investment (Zou *et al.*, 2010). Legal requirements imposed by the governments, together with moral obligations linked to corporate and social responsibility prioritise safety as one of key

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objectives in a construction project. An accident may lead to prosecution and claims that can jeopardise the financial health of a company (Holt, 2005). The reputation of a company is also at stake when it does not implement proper safety measures to protect the safety and wellbeing of its employees (Lingard and Rowlinson, 2005).

This favourable environment for safety should support the growth of construction safety research. However, statistics reveal that safety performance of the construction industry remains somewhat flat in recent years (Holt, 2005). A gap may exist between the direction taken by construction safety researchers and the nature of construction safety practices, which may lead to the lack of implementation of research findings in the industry. Consequently, there is a need to scrutinise the research methods that are adopted in current construction safety research.

If viewed as a set of practices constituted by competences that a person learns through engagement and participation in daily activities (Baarts, 2009), learning can be seen as crucial for construction practitioners, and especially workers, to perform their works safely. Learning takes place in local practices where people collaborate and cooperate to solve daily issues (Styhre, 2006). A safe workplace, therefore, is the result of constant engineering of diverse elements (e.g. skills, materials, interpersonal interactions) which are integral to the work practices of various project stakeholders. Learning about safety involves taking part in the social world, i.e., it takes place among and through others (Gherardi and Nicolini, 2002). Seeing, saying, showing, telling, and learning-by-using are how individuals acquire new skills and knowledge (Styhre, 2006).

Despite this, however, most construction safety research still adopts the assumption that knowledge and learning are primarily individual and mental processes, a substance that can be stored and transferred as required (Gherardi and Nicolini, 2000). Although the importance and necessity of this realist approach is obvious, construction safety research should also recognise the alternative paradigm which implies that safety knowledge and learning are social and cultural phenomena developed through interactions of individuals with each other, and with non-human artefacts, while performing works (Wadick, 2006). Such a perspective demands appropriate theoretical and methodological positions if the safety knowledge and practice are to be understood as enmeshed together.

Based on this line of reasoning, the aim of this research is to examine current research practices and recommend a new approach for conducting construction safety research which may contribute to safety performance improvement. Initially we examine the research methods adopted by recent construction safety research. By understanding the prevailing methods, their implications to construction safety management and performance can be inferred. Following these we explore the potential of multi-methodological research design for conducting construction safety research that encourages researchers to collaborate with industry practitioners for making contribution to improve safety performance in the construction industry. This approach is in line with the “coproduction research” proposed by Green *et al.* (2010) aiming at generating new knowledge which should meet the needs of two sets of audiences, i.e., researchers and practitioners. The outputs of the research should not only provide short-term benefit for industry partners, but also contribute to the advancement of the conceptual understanding beyond the immediate context of the research.

REVIEW OF CONSTRUCTION SAFETY RESEARCH METHODS

Two key issues will be discussed: (1) the process of selecting publications to represent the current state of construction safety research and (2) the analysis of the research methods adopted in the construction safety research.

Selecting publications

Papers related to construction safety published in, 2009 in highly-ranked journals and conference proceedings, according to the criteria set in ERA (Excellence in Research for Australia), were selected for investigation. The year, 2009 was the latest year in which all research papers are accessible at the time of writing of this paper. The papers selected had to meet two requirements. First, the journal or conference where the paper was published receives A+ or A rating from ERA and second, the journal or conference must be related to construction management or recognised in this discipline (Australian Research Council, 2010). We acknowledge that there is no definite way of discerning a “highly-ranked” journal or conference. We also acknowledge that there are other measures for journal quality and ranking, such as SSCI (social science citation index) and impact factor, which are other two measures broadly accepted as determinants of quality and ranking of a journal. However, due to the geographical context of where this paper was initially written, which is Australia, ERA was considered as the most prominent indicator. Based on these requirements, the publications selected for this research are:

1. Journal of Construction Engineering and Management (ERA: A+) published by American Society of Civil Engineers (ASCE, 2010).
2. Engineering, Construction and Architectural Management (ERA: A+) published by Emerald Group (2010).
3. Construction Management and Economics (ERA: A) published by Taylor and Francis Group (2010).
4. Safety Science (ERA: A) published by Elsevier (2010b).
5. International Journal of Project Management (ERA: A) published by Elsevier (2010a).
6. CIB W099 Safety and Health in Construction Conference (ERA: A) is part of the task groups and working commissions of International Council for Research and Innovation in Building and Construction (CIB, 2010).

Analysis of research methods adopted in construction safety research

Table 1 shows the total numbers of papers and those related to construction safety published in the six selected publications. In total, 561 papers were published in, 2009. Among these, 88 papers (15.7%) are related to construction safety.

The 88 construction safety papers were analysed to determine the research methods adopted. Some papers do not clearly state their methodological positions, thus efforts were made to identify the methodology based on the explanation provided in the papers. Four broad classifications were used to summarise the methods adopted within the selected papers (classifications are based on the work of Dainty [2008]):

1. Quantitative: adopting quantitative methods rooted in a positivist view.
2. Qualitative: adopting qualitative methods rooted in an interpretivist view.
3. Mixed methods: using quantitative and qualitative research methods or inductive and deductive logical systems.
4. Review and conceptual (others): generally using literature review or previous studies to formulate theories or develop conceptual frameworks.

Table 1 Number of papers published in, 2009 in the six selected publications

Publications	Papers in, 2009	Construction safety papers in, 2009
Safety Science	144	6 (4.2%)
Journal of Construction Engineering and Management	144	15 (10.4%)
Construction Management and Economics	88	4 (4.5%)
Engineering, Construction and Architectural Management	36	2 (5.6%)
International Journal of Project Management	83	1 (1.2%)
CIB W099 Safety and Health in Construction	66	60 (90.9%)
Total	561	88 (15.7%)

Table 2 shows the overall picture of the research methods adopted in construction safety research. Thirty-eight papers (43.2%) used quantitative approach, 21 papers (23.9%) used qualitative approach, 8 papers (9.1%) can be considered as mixed methods research, and 21 papers (23.9%) were considered as review or conceptual papers. The results show that quantitative research is the dominant methodology adopted by researchers, which is aligned with Bryman's (2008) who stated that quantitative research is the dominant methodology in social research. A study by Dainty (2008) examined the methods adopted in construction management research by examining all papers published in Construction Management and Economics journal in, 2006. He found that quantitative research is the most popular methodology in construction management research (71%), followed by mixed methods research (11.2%), review or other papers (9.4%), and qualitative research (8.4%).

Table 2 Methodologies adopted in construction safety research papers

Publications	Quantitative	Qualitative	Mixed	Review or conceptual
Safety Science	4	1	1	0
Journal of Construction Engineering and Management	10	1	2	2
Construction Management and Economics	2	2	0	0
Engineering, Construction and Architectural Management	0	2	0	0
International Journal of Project Management	0	0	1	0
CIB W099 Safety and Health in Construction	22	15	4	19
Total	38	21	8	21
Percentage (%)	43.2	23.9	9.1	23.9

Further efforts were made to classify the research methods used within the qualitative and mixed methods research as presented in Table 3. Several studies used more than one qualitative research methods, thus the numbers in Table 3 are greater than the numbers of papers adopting qualitative and mixed methods research identified in Table 2. Just over half of construction safety researchers used interviews (51.2%) as their main qualitative research method, followed by observation (22%), action research (12.2%), ethnography (7.3%), and content analysis (7.3%) respectively. Again, this is aligned with Dainty's (2008) study in which interviews (both individual and group) are the majority of research methods used in qualitative and mixed methods research.

Table 3 Qualitative research methods used in construction safety papers

Publications	Interview	Observation	Action research	Ethnography	Content analysis
Safety Science	2	1	0	0	0
Journal of Construction Engineering and Management	2	3	0	0	0
Construction Management and Economics	2	0	1	1	0
Engineering, Construction and Architectural Management	2	1	0	0	2
International Journal of Project Management	1	0	0	0	0
CIB W099 Safety and Health in Construction	12	4	4	2	1
Total	21	9	5	3	3
Percentage (%)	51.2	22.0	12.2	7.3	7.3

DISCUSSION

The analytical results of the construction safety research papers published in, 2009 indicates that the researchers in this area mainly still adopt the objectivist philosophical position as reflected by the high percentage of quantitative research papers. This may imply that organisational factors, such as safety policy, safety management frameworks and tools, and safety procedures, have been the main objects of construction safety research. This philosophical standing believes that such factors should be improved and adhered to maintain and improve safety performance in the construction industry. Quantitative research may also be employed to investigate the influence of human factors on safety. Such research typically aims to identify certain characters or competencies that need to be possessed or developed for effectively managing construction safety. It intends to generalise the findings and sometimes disregards the context in which the findings can be applied. Frequent use of quantitative research methods may also reflect that past research has focused more on "what" has happened rather than "why" and "how" construction safety problems happened. Another possible implication would be that research grant applications using quantitative research methodology might have been more fundable and implementable, as compared to those adapting longitudinal qualitative research methods.

However, researchers should recognise the fact that social and cultural factors play a very important role in safety knowledge making and learning. Construction workers learn about safety knowledge and skills from practice which means that safety knowledge and skill development tends to rest on specific workplace traditions. Workers attempt to regulate each other and themselves through informal safety rules developed from this model of learning (Baarts, 2009). In the context of research, it is important to move one step back and do more foundational work by exploring how knowledge is constructed in the first place (Tsoukas and Mylonopoulos, 2004).

Therefore, it may be prudent for researchers to adopt more constructivist ontological and interpretivist epistemological positions. About 33% of construction safety research papers published in, 2009 adopted qualitative and mixed methods research, which typically are rooted in these constructivist and interpretivist philosophical assumptions. This number may seem low, but it is considerably higher than Dainty's (2008) study in which qualitative and mixed methods research only represent less than, 20% of construction management research.

The majority of construction safety researchers used interviews (both individual and group) as their main qualitative method. Leedy and Ormrod (2005) pointed out the issue with interviews is that people may say what should have happened based on their attitudes and beliefs rather than what actually happened. Hammersley (2003) went further by suggesting that researchers have become obsessed with interviews as a means of discovery without considering its limitations. The critics argue that interview responses are heavily influenced by the activities of the interviewer. Hence, interview participants are more focused on self-presentation and the persuasion of others, rather than presenting facts about themselves or the social entities under investigation. This shows the importance of data from different resources to triangulate the inferences and outcomes of these interview data (Dainty, 2008) because interviews alone may not reveal the true nature of construction safety issues.

Table 3 indicates that mixed methods research was adopted by 12% of researchers. Mixed methods research is not as simple as approaching an object of study from different angles using different methods. On the contrary, this approach is complex because of the application of different ontological and epistemological underpinnings of research methods, consisting of combinations of methods. Researchers should be aware of how they employ a specific method and what this method is actually pointing at, and how this relates to the ways in which they employ other methods (Grix, 2004). Dainty (2008) suggested that it is legitimate and desirable to use multiple theoretical models and methodological approaches if established models and understandings are to be questioned and knowledge furthered, which is the case for the current state of construction safety research. Mixed methods research design provides an alternative to mono method research which may enrich and generate more reliable research results (Bergman, 2008; Mingers, 2001).

Three limitations in this research are worthy of discussion. Firstly, the six selected publications may not sufficiently represent the entire population and current trends of construction safety research. However, despite this limitation, the six publications are considered among the best in the field and it is assumed that the papers published within these publications represent the benchmarking quality globally. Secondly, many papers that were studied in this research do not clearly state their methodological positions. Consequently, the interpretation of the research methods adopted within the papers is itself interpretative which may include bias. Thirdly, this research draws its conclusions from a single year's worth of papers. There is a possibility that papers published in, 2009 were anomalous, thus do not represent the trends of construction safety research.

PROPOSED MIXED METHODS RESEARCH DESIGN FOR CONSTRUCTION SAFETY RESEARCH

The nature of construction safety practices shows that safety learning as well as safety knowledge and safety skill development takes place in the social world, among and through other people (Gherardi and Nicolini, 2002; Wadick, 2006). Construction safety research, however, still predominantly focuses on cognitive process of safety implementation. This may lead to the lack of relevancy and practicality of research findings to industry practitioners. Consequently, integration between construction safety research and the construction industry, and between theory and practice, is needed to overcome this issue. Following this line of reasoning, a new mixed methods research design for construction safety research is proposed as illustrated in Figure 1.

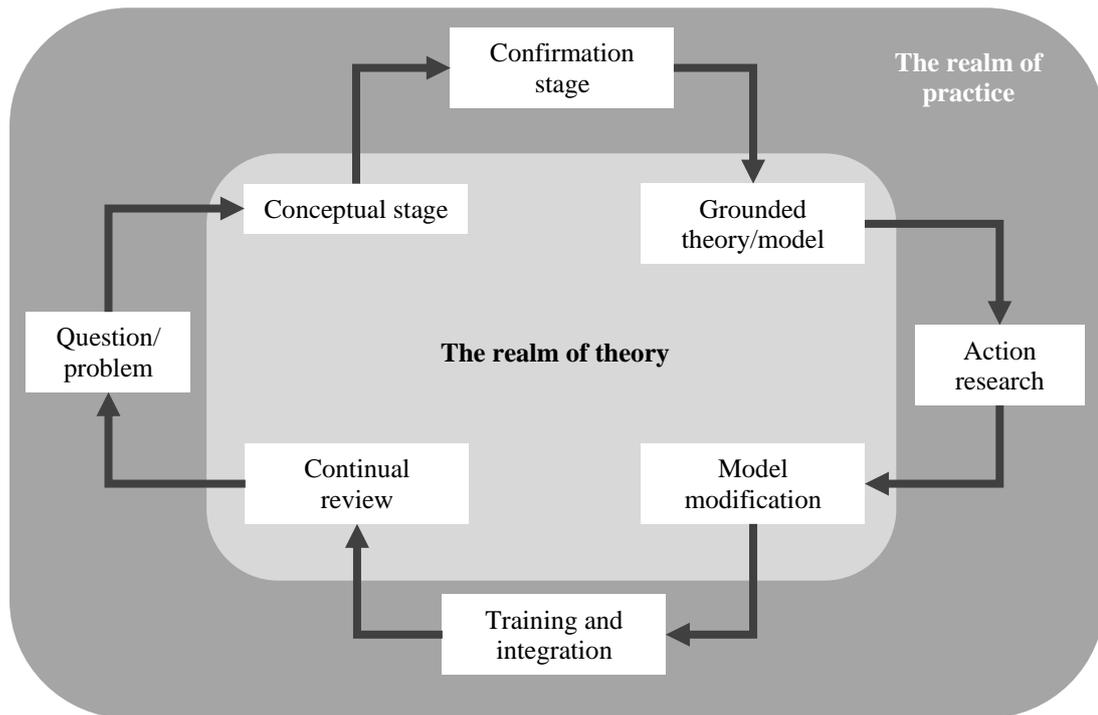


Figure 1 Integration model of theory and practice in construction safety research

It should be noted that research can start at any stage of the model proposed in Figure 1, which essentially depends on the research question, i.e., theoretical or industrial problem derived. For convenience and ease of understanding, however, we explain from the question/problem stage on the left hand side of the model. In this stage, industrial problem is the factor that drives the research in which practitioners approach researchers to solve the problem. In order to solve this problem, researchers should begin by examining past studies and theories related to the particular area under investigation. This conceptual stage aims to gain a firm grasp and deeper understanding on the rationale and background of the topic under scrutiny. A conceptual model may need to be developed to give an overview of the research and show the relationship between various variables that will be investigated.

The next stage is the confirmation stage to make sure that the research problems and objectives are relevant and according to the need of construction practitioners. The aim of this stage is to truly understand the nature of construction safety practices and the context of the issue that will be investigated. Quantitative or qualitative methods can be used depending on the type of data that are needed. However, to gain richer understanding of the issue as well as because of the exploratory nature and inductive reasoning of the investigation in this stage, we support the use of qualitative methods. An ethnographic research design or, at the least, observation is recommended to truly understand the need of the construction companies involved in the research and to confirm or amend the conceptual framework developed in the previous stage. Based on the data and findings from the confirmation stage, researchers together with industry partners can formulate a grounded theory or model which is deemed essential to solve the research problems and improve safety performance. Grounded theory studies are valuable when existing theories about a phenomenon are insufficient or lacking (Leedy and Ormrod, 2005).

The grounded theory or model is then put into practice through action research in the participating companies. Action research is a research method which is carried out

with a team approach that includes researchers and members of organisation (those who are considered as stakeholders in the research effort). The goal of action research is not only for the sake of the research or testing a theory, but also to create a positive social change (Berg, 2009). The purpose of this stage is to find “glitches” before the full implementation of the theory or model. Both quantitative and qualitative methods can be used during this stage to gather data and information on the effectiveness of the theory or model as well as getting feedback for further improvement. The findings of the action research should result in theory or model modification and improvement. The final theory or model then can be integrated into the construction companies through proper communication and training. Afterwards, continual reviews are essential to find opportunities for further improvement. When a new problem warranted further research is found, the cycle begins again.

This proposed research design should not be viewed as rigid nor be implemented by neglecting the research question that need to be answered. Each research study requires different kinds of data to be collected, thus research methods employed in each stage may vary from one research study to another. This approach, therefore, should be viewed as a guideline or a plan in which each stage serves as a milestone for researchers to reflect on what needs to be done and how each action can positively impact on the construction industry practice.

Researchers who consider adopting the mixed methods research design proposed in this paper should realise that poorly conducted research will generate suspect findings regardless how many methods are employed. There is no point of collecting more data simply on the assumption that more is better (Bryman, 2008). Furthermore, mixed methods research may produce contradictory (or incompatible or incommensurable) findings/knowledge in which the quantitative and qualitative results do not agree. In addition, having different samples and sample sizes as well as the need of sufficient skills and time to conduct mixed methods research may have significant consequences. Researchers must be aware of these challenges and consider strategies to address them (Creswell, 2008). Lastly, the mixed methods research design proposed in this paper must be adopted when it is appropriate for answering the research questions defined to achieve the research aims and objectives.

CONCLUDING REMARKS

The research direction taken by construction safety researchers may not align with the practical needs of the construction industry. This gap could have lead to lack of implementation of research findings in safety management practices. There is a need to find a way to align or integrate construction safety research and on-site safety management practices.

Review of construction safety research papers published in, 2009 revealed that quantitative research is the dominant methodology followed by qualitative and mixed methods research respectively. This finding indicates that researchers predominantly adopt an objectivist philosophical assumption which views safety knowledge and skills as products that can be stored somewhere and disseminated into the minds of others as required, typically through a classroom-like training setting. Although the importance of this approach is evident, it is necessary to realise that learning is also a process that takes place among and through interactions with other people and artefacts. In this context, researchers should pay attention to the reality and nature of construction safety practices.

A mixed methods research design has been proposed to facilitate the collaboration between researchers and practitioners in the area of construction safety. Through this approach, it is expected that research findings will become more relevant and useful to construction practice, while at the same time contributing to the advancement of conceptual understanding. This research approach encourages iteration between the realms of theory and practice, but often demands the combination of multiple forms of research in order to provide insights to "what" and "why and how" research questions. It should be noted that implementing this proposed research design is not an easy task and it courage on the part of the researchers. Researchers must be aware of the challenges of conducting mixed methods research and justify the appropriateness of the approach to answer the research questions.

REFERENCES

- American Society of Civil Engineers (2010), *Journal of Construction Engineering and Management*, ASCE, <http://www.asce.org/Journal.aspx?id=2147486635> [Date accessed 26 November, 2010].
- Australia Safety and Compensation Council (2010), *Information sheet – construction*, ASCE, <http://www.safeworkaustralia.gov.au/> [Date accessed 25 April, 2010].
- Australian Research Council (2010), *The Excellence in Research for Australia (ERA) Initiative*, ARC, <http://www.arc.gov.au/era/> [Date accessed 24 November, 2010].
- Baarts, C. (2009), "Collective individualism: the informal and emergent dynamics of practising safety in a high-risk work environment", *Construction Management and Economics*, **27**(10), 949-957.
- Berg, B. L. (2009), *Qualitative research methods for the social sciences*, 7ed., Allyn & Bacon, Boston, USA.
- Bergman, M.M., (2008, "The straw men of the qualitative-quantitative divide and their influence of mixed methods research", in Bergman, M.M. (Ed.), *Advances in mixed methods research: theories and applications*, 11-21, Sage, Los Angeles, USA.
- Bryman, A. (2008), *Social research methods*, 3ed., Oxford University Press, Oxford, UK.
- Conseil International du Bâtiment (CIB) (2010), *International Council for Research and Innovation in Building and Construction*. <http://www.cibworld.nl/> [Date accessed 24 November, 2010].
- Creswell, J. W., Clark, V. L. P. and Garrett, A. L. (2008), "Methodological issues in conducting mixed methods research designs!", in Bergman, M.M. (Ed.), *Advances in mixed methods research: theories and applications*, 66-83, Sage, Los Angeles, USA.
- Dainty, A. (2008), "Methodological pluralism in construction management research", in Knight, A. and Ruddock, L. (Eds.), *Advanced research methods in the built environment*, 1-13, Wiley-Blackwell, Oxford, UK.
- Elsevier (2010a), *International Journal of Project Management*, http://www.elsevier.com/wps/find/journaldescription.cws_home/30435/description [Date accessed 26 November, 2010].
- Elsevier (2010b), *Safety Science*, http://www.elsevier.com/wps/find/journaldescription.cws_home/505657/description#description [Date accessed 26 November, 2010].

- Emerald Group (2010), *Engineering, Construction and Architectural Management*, <http://www.emeraldinsight.com/journals.htm?issn=0969-9988> [Date accessed 26 November, 2010].
- Gherardi, S. and Nicolini, D. (2000), "To transfer is to transform: the circulation of safety knowledge", *Organization*, **7**(2), 329-348.
- Gherardi, S. and Nicolini, D. (2002), "Learning the trade: a culture of safety in practice", *Organization*, **9**(2), 191-223.
- Green, S. D., Kao, C- C. and Larsen, G. D. (2010), "Contextualist research: iterating between methods while following an empirically grounded approach", *Journal of Construction Engineering and Management*, **136**(1), 117-126.
- Grix, J. (2004), *The foundation of research*, Palgrave Macmillan, Hampshire, UK.
- Hammersley, M. (2003), "Recent radical criticism of interview studies: any implications for the sociology of education?", *British Journal of Sociology of Education*, **24**(1), 119-126.
- Holt, A. S. J. (2005), *Principles of construction safety*, Blackwell Science, Oxford, UK.
- Leedy, P. D. and Ormrod, J. E. (2005), *Practical research: planning and design*, 8ed., Pearson, Upper Saddle River, NJ, USA.
- Lingard, H. and Rowlinson, S. (2005), *Occupational health and safety in construction management*, Spon Press, Oxon, UK.
- Mingers, J. (2001), "Combining IS research methods: towards a pluralist methodology", *Information System Research*, **12**(3), 240-259.
- Murie, F. (2007), "Building safety—an international perspective", *International Journal of Occupational and Environmental Health*, **13**(1), 5-11.
- Sun, A. C. S. and Zou, P. X. W. (2010), "Understanding the true costs of construction accidents", *Proceedings of CIB World Congress*, 11-13 May, 2010, Salford, Greater Manchester, UK.
- Styhre, A. (2006), "Peer learning in construction work: virtuality and time in workplace learning", *Journal of Workplace Learning*, **18**(2), 93-105.
- Taylor & Francis Group (2010), *Construction Management and Economics*, <http://www.tandf.co.uk/journals/journal.asp?issn=0144-6193&linktype=1> [Date accessed 26 November, 2010].
- Tsoukas, H. and Mylonopoulos, N. (2004), "Introduction: knowledge construction and creation in organizations", *British Journal of Management*, **15**(S1), S1-S8.
- Wadick, P. (2006), *Learning safety in the building industry*, CFMEU – Construction and General Division, NSW Branch, <http://www.cfmeu-construction-nsw.com.au/pdf/pwreslearnsafetybldgind.pdf> [Date accessed 4 January, 2011].
- Zou, P. X. W., Sun, A. C. S., Long, B. and Marix-Evans, P. (2010), "Return on investment of safety risk management system in construction", *Proceedings of CIB World Congress*, 11-13 May, 2010, Salford, Greater Manchester, UK.