Knowledge Transfer: A Model Framework for Construction Knowledge Integration

Moh’d Azian Zaidi and Hilary Davies
School of Architecture & Building
Deakin University, Geelong, Australia

ABSTRACT
Managing information and knowledge in the construction industry is an important focus for research. The goal is to expedite better integration of construction knowledge amongst the stakeholders. Better use of this knowledge could allow the building industry to achieve quality outputs making best use of resources – the linked goals of time, cost and quality. Information networks and knowledge transfer are central to this and are recognized as integral to an industry strategy to improve productivity. However, poor delivery of information to those at the construction site and lack of effective methods of transferring knowledge between parties involved in construction become major challenges. Based on a critical review of literature and an interview survey, this paper identifies the information networks adopted in the Malaysian construction industry and models these using four knowledge transfer components classified as ‘control’, ‘innovation’, ‘best practice’ and ‘audit’ element. Knowledge integration practices - attitude, communication, skills, commitment and monitoring; and factors related to information barriers including accessibility, service delivery, information updates and publication, were identified as critical features for the success of knowledge integration in the Malaysian construction industry. A framework for knowledge transfer is proposed to promote better practices in the Malaysian construction industry.

KEYWORDS
construction knowledge, information flow, knowledge transfer

BACKGROUND
The challenge to integrate and share knowledge in the construction industry has become an important agenda for many researchers worldwide. The issues relate to a lack of quality revealed through building defects, poor building performance and poor management of the construction project (Wong, 1996; Georgiou et al. 2000). As construction knowledge is recognized as a process to integrate information at every level of the construction process (Griffith and Sidwell, 1997; Nima et al., 2001), the factors that contribute to its success need to be identified. Poor practices relating to construction
process, that include lack of interaction, miscommunication and inappropriate use of knowledge by industry personnel, suggest that this issue needs to be prioritized. Many construction projects do not receive feedback input due to the lack of a formal and explicit knowledge base, resulting in low quality outputs and poor building performance (Jergeas and Van der Put, 2001).

One of the factors closely related to this problem is caused by inadequate transfer of information in the building production process. Information is a key component for updating and optimizing knowledge. This information must be managed to bring in value. Previous research by Zaidi and Davies (2009, 2010) has proposed a model of information networks that includes the elements of ‘control’, ‘innovation’, ‘best practices’ and ‘audit’ as being relevant areas to explore to improve knowledge transfer. Developing from this work, this paper has the following objectives:

1. To explore how the model of information networks (‘control’, ‘innovation’, ‘best practices’ and ‘audit’) contributes to construction knowledge integration;
2. To identify any areas for improvement in knowledge transfer that could improve construction knowledge integration as well as to ensure better building quality in the Malaysian construction industry.

Inefficiency in handling information does not depend solely on the industry process or the technologies adopted (Titus and Brochner 2005). It requires good social networks to create a better learning environment in such communities. Miscommunication and lack of trust prove to be challenges, for example, Faniran et al. (2001) suggest that poor interaction between different disciplines during the design and construction process explains the poor coordination and integration often seen during projects. Therefore, this paper offers a model of the knowledge transfer process that could assist industry players to develop better construction knowledge integration through effective handling of information.

**CONSTRUCTION KNOWLEDGE INTEGRATION**

Knowledge in construction project usually understands as technical knowledge, practical knowledge, experience and skills (Fong, Hills and Hayles, 2007). This knowledge could be exploited for the maximization of project goals and building performance by the integration of construction knowledge in the building process (Griffith and Sidwell, 1997). The best use of knowledge and experience in planning, engineering, procurement and field of operations to achieve overall objectives is essential for the accomplishment of the project success (Arditi et al. 2002).
Griffith and Sidwell (1997) have argued that integration of construction knowledge should not be focused only on the design and construction relationships, but must examine the total building production process throughout a project’s life cycle (Table 1).

<table>
<thead>
<tr>
<th>Project Phases</th>
<th>Construction Knowledge that needs to be integrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasibility, Conceptual Planning and Procurement Stages</td>
<td>Client's corporate objectives; client's project requirements; project strategy; project priorities - time, cost, quality; project team selection; definition of relationships, responsibilities and authority; type of project; location, site conditions and environment; resources; legislation and regulation; climatic influences; project risk; form of contract; contract negotiation; and contract administrative procedures</td>
</tr>
<tr>
<td>Design Stages</td>
<td>Design concepts; specifications; construction details; task dependency; standardisation; tolerances; dimensional coordination; and drawings and communication.</td>
</tr>
<tr>
<td>Construction and Management Stages</td>
<td>Construction knowledge; skill base; construction methods; sequencing; resource deployment; standards and control of quality; organisational structure; management and supervisory style; industrial relations; planning and progressing methods; material procurement; use of plant and equipment; site layout and temporary facilities; and site safety</td>
</tr>
<tr>
<td>Post-Construction Stages</td>
<td>Installation and commissioning; operational requirements; user requirements; and life cycle provision and maintenance.</td>
</tr>
</tbody>
</table>

Source: Griffith and Sidwell (1997) pp301-302

Nima et al. (2001) emphasise integration of construction knowledge depends on the role of contractor’s through every stage of the construction process. Nima et al. (2001) propose three aspects - the need for individual knowledge and experience, advanced information technology requirements and the need for innovation during the whole building life cycle as the basic fundamental components for construction knowledge integration. Table 2 illustrates the roles of contractor personnel offered by Nima et al. (2001) in knowledge integration.
Table 2 – The roles of contractor personnel for construction knowledge integration

<table>
<thead>
<tr>
<th>Project Stages</th>
<th>Contractor Personnel Roles</th>
</tr>
</thead>
</table>
| Project constructability enhancement during conceptual planning | i. A project team (all stakeholders) should be formed to take constructability issues into consideration from the outset of the project and through all its phases.  
ii. The project constructability programme should be discussed and documented with the participation of all project team members.  
iii. Experienced individuals should be involved in early project planning so that problems at the interface between design and construction can be avoided.  
iv. Construction methods should be discussed and analysed in conjunction with selection of contract type.  
v. Site layout should be devised for efficient construction, operation and maintenance. |
| Project constructability enhancement during design and procurement phase | i. Design and procurement schedules should be dictated by construction sequence.  
ii. The use of advanced information technology could improve communication between stakeholders and enhance constructability.  
iii. Designs should be reviewed (and simplified) by qualified construction personnel  
iv. Project elements should be standardised and modularisation and pre-assembly utilised.  
v. The project technical specifications should be simplified and configured to achieve efficient construction performance.  
vi. Project design should take into consideration the accessibility of construction personnel, materials and equipment to the required position inside the site.  
vii. Design should facilitate construction during adverse weather conditions. |
| Project constructability enhancement during field operations phase    | i. Field tasks sequencing should be configured in order to minimise damage or rework; scaffolding/formwork; congestion on project elements.  
ii. Innovation – utilise new methods, construction materials, pre-assembly, or modification of the available tools to increase productivity.  
iii. Evaluate documentation and feedback any issues of the constructability concepts used throughout the projects. |


Nima et al. (2001) also concluded that construction personnel must not only be knowledgeable in the technical aspects of engineering and construction but also be able to manage people and be good organizers and administrators. Practical knowledge, good collaboration and effective monitoring were suggested as essential to improve knowledge.
integration. Thus it is requires consideration of technical, managerial and relationship skills to incorporate all aspects and personnel involved in a building project. These considerations remain as challenges for the construction industry trying to improve information and knowledge transfer.

THE ROLE OF INFORMATION

Information is a part of construction industry communication and critically influences the conception and completion of a building project (Coulson, 2004). In the building production process, information is a significant input or resource. The construction process involves repetitively using a network of orderly linked activities which use information for transforming inputs to outputs (Titus and Brochner 2005). Information is usually captured from a client, design team or contractor and disseminated to generate project outputs in the construction life cycle (Alshawi and Underwood 1996).

‘Information’ could be in the form of a message, usually a document, and/or an audible or visible communication, which has a sender and a receiver (Eliufoo, 2005). According to Nonaka and Takeuchi (1995), information could provide a new point of view for interpreting events or objects. Beijerse (2000) defines information as the amount of data that needs to be distributed for any organization to function successfully. However, information is not a ‘free good’ and requires an appropriate level of understanding. Accordingly Quintas et al. (1997), suggest information is only valuable within a context where other forms of knowledge are brought to bear.

In the construction process, information should be elicited from all industry stakeholders and be effectively integrated (Eliufoo 2005). Information needs in the construction industry sector include client needs for information to help with their development planning; consultant teams need detailed information to help them monitor and control construction activities; and contractors need information to program and to enable satisfactory completion of the project. Therefore, in the construction project life cycle, information and its transfer mechanisms should be brought together for all activities.

Project success has traditionally been represented as the ‘golden triangle’ of cost, time and quality objectives. However, a major challenge in achieving project success is how to effectively integrate construction knowledge and experience into each phase of the project development process (Anderson et al. 2000). Several studies have recognized that the problems relating to a lack of information and poor knowledge sharing constitute a major issue requiring urgent improvement (Jergeas and Van der Put 2001; Arditi et al. 2002; Walker and Shen 2001). These authors highlight relationship issues such as lack of trust, lack of commitment and poor communication as major challenges. Arditi et al. (2002), suggest that construction knowledge has also been hindered by designers’
misunderstanding or lack of appreciation of construction requirements. Often, contractors are not invited to participate or take part in design activities, when they can provide invaluable construction inputs at early stages of the building production process (Alshawi and Underwood 1996). Saghatforoush et al. (2009) also recognized the lack of contractor involvement in the early phase of the design process and Malaysian contractors’ shortage of knowledge as main barriers for project success.

Information is recognized as a key driver for success in the building production process (Coulson 2004; Titus and Brochner 2005; Chen and Mohamed 2008). Knowledge and information transfer have been identified as areas in which the construction industry must achieve significant improvement (Zaidi and Davies 2009). However, information transfer is generally given little attention in many country’s construction activities including Malaysia (Wong, 1996; de Silva et al. 2004). There is thus a lack of integration in construction inputs and inadequate transfer of information, often resulting from lack of appreciation of the potential contributions of all parties involved in a construction project, the contractual process itself with its conflicting objectives and the often adversarial nature of construction contracts, all of which result in a general lack of communication which in turn creates problems for construction knowledge integration.

PRODUCTION OF INFORMATION FROM KNOWLEDGE PROVIDER AGENCIES

To demonstrate the proposed framework, this paper viewed information in four different of knowledge providers agencies. Knowledge can primarily be described as something that makes data and information manageable (Beijerse, 2000). This data and information are produced from different sources of organizations. Therefore, a model incorporating four different components of information sources are proposed in order to integrate construction knowledge effectively (Zaidi and Davies 2009, 2010). These components - ‘control’, ‘innovation’, ‘best practice’ and ‘audit’ are explained as follows:

a) **Control Element.** In the construction process, ‘control’ refers to any information received from any public agency including any law, regulation, guideline or policy produced by local, national or international bodies. This also refers to the enforcement of building regulations made by government in order to ensure that any construction project complies with standards. Contractors are expected to comply with building codes, standards and good building practices; therefore information from the control element needs to be effectively communicated to ensure contractors are up-to-date with current requirements.

b) **Innovation Element.** Under the innovation element, optimization of construction knowledge could be achieved through an effective integration of information
produced by research and development (R&D) agencies. Effective use of R&D information could be one of the strategies to increase construction project performance (Panuwatwanich et al. 2009). Latest findings such as new construction materials, construction techniques or any novel approach could achieve better construction project quality and increase productivity and constructability. Given the ever increasing amount of information being generated, gaining attention for important new discoveries is a continuing challenge for R&D agencies.

c) *Best Practice Element.* Best practice is an initiative by governments and research agencies to motivate key players in the industry to apply proper building practice. This could be achieved through training programs offered by any public or private organization in the construction industry. Information related to any new technique such as supply chain management, value engineering, partnering, total quality management (TQM) etc is invaluable for construction personnel to improve their skills and practices.

d) *Audit Element.* Integration of construction knowledge is not solely dependent on the effective delivery of information from outside agencies from the control, innovation and best practice elements. The requirement to receive feedback on project performance should become one of the essential strategies for construction knowledge to succeed. Therefore this paper suggests the audit element as an additional way to integrate construction knowledge in the construction process. Audit can include developing databases of projects to be used for benchmarking and setting Key Performance Indicators (KPI’s). Table 3 maps these elements against information sources for Malaysia construction industry.

THE STUDY: INDUSTRY PRACTITIONERS PERCEPTION OF KNOWLEDGE TRANSFER APPLICATION IN THE MALAYSIAN CONSTRUCTION INDUSTRY

The study was carried out to investigate those factors that could contribute to the success of information and knowledge transfer in the Malaysian construction industry. The first phase was to define the problem and the scope of research. A literature search of construction project and knowledge management provided a framework for understanding information transfer concepts in integrating construction knowledge. The second part of the research was a survey of industry practitioners.
Table 3 – Information sources for construction knowledge integration in Malaysia

<table>
<thead>
<tr>
<th>Information Element</th>
<th>Strategy and Initiatives</th>
<th>Current Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>Building Control and Legal Aspects</td>
<td>Applied the ‘conventional method’ of building plan assessment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduced the ‘One Stop Centre’ (OSC) system in monitoring building plan submission process.</td>
</tr>
<tr>
<td></td>
<td>Construction Board Establishment</td>
<td>Establishment of the Construction Industry Development Board (CIDB) Malaysia</td>
</tr>
<tr>
<td></td>
<td>Standardization Strategy</td>
<td>Materials and products inspected and certified by the Standard Institute of Research and Innovation (SIRIM) Establishment of the Malaysian Standard (MS)</td>
</tr>
<tr>
<td>INNOVATION</td>
<td>Research Initiatives</td>
<td>Establishment of the Construction Research Institute of Malaysia (CREAM)</td>
</tr>
<tr>
<td></td>
<td>Innovation Initiatives</td>
<td>Establishment of the QLASSIC and MCEIA approach in assessing quality of construction.</td>
</tr>
<tr>
<td>BEST PRACTICES</td>
<td>Quality Management Approach and Initiatives</td>
<td>International Standard of Organization (ISO) application (Encouraging construction company to implement ISO procedure)</td>
</tr>
<tr>
<td>AUDIT</td>
<td>Auditing Process Initiatives</td>
<td>Initiated the Blue Ribbon Award for outstanding housing project. ISO certification</td>
</tr>
</tbody>
</table>

Survey approach

An interview survey of thirteen industry practitioners, including company directors, project managers, engineers and site supervisors from different construction organizations, was employed to assess factors considered to promote successful construction knowledge integration. These participants were selected at random from various regions in Malaysia including Kuala Lumpur, Selangor, Perak, Negeri Sembilan and Terengganu.

To ensure a substantial amount of expertise for the interview participants, individual positions in the company is the key criteria used to select the members. A sample of three director, two project manager, four engineers, three quantity surveyors and one project executive involves for this interviews. The lists of the respondent are shown in Table 4.
Table 4 – List of interview respondents

<table>
<thead>
<tr>
<th>Position</th>
<th>Nos. of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Director</td>
<td>3</td>
</tr>
<tr>
<td>Project/Construction Manager</td>
<td>2</td>
</tr>
<tr>
<td>Engineer</td>
<td>4</td>
</tr>
<tr>
<td>Quantity Surveyor</td>
<td>3</td>
</tr>
<tr>
<td>Project Executives</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
</tr>
</tbody>
</table>

In the interview process, a semi structured interview with open ended question was used. The basic themes of the interview were classified in two parts that consisted of the themes for critical issues in integrating construction knowledge in section A. Section B consisted of knowledge transfer questions which included the importance of information sharing and information transfer applied in construction organizations. The survey results were combined with the literature search to yield knowledge issues and their impacting factors. Finally, a set of conclusions and recommendations was derived after analysing the outcomes and results of the survey.

Section A: factors affecting knowledge transfer

Based on the survey interview conducted, factors relating to poor attitude, communication, skills, commitment and poor monitoring were perceived by the interviewees as critical factors that influence construction knowledge integration. In this interview, the majority of respondents agreed attitude has a high impact influencing the success of knowledge transfer. This survey found that every respondent voiced their concerns of poor attitude such as poor feedback from staff in public agencies and delays in confirmation of any construction task by the staff that could influence successful knowledge transfer. Attitude was considered an important aspect of knowledge transfer.

Communication problems were listed as a second contributor to the knowledge transfer barrier. This factor allows delays to the project progress due to incompetent communication skill. Lack of informal discussion and lack of involvement by the contractor in delivering input to the designer in early stages of the design could affect the construction work during implementation stages. Besides that, poor understanding of the documentation including construction work procedure and guideline was identified as a main reason for this problem.
In general, construction expertise is in the form of written documents (explicit knowledge) and in people’s head (tacit knowledge) (Mohamed and Anumba, 2006). According to Fong, Hills and Hayles (2007), skills are recognized as one of the factors that could influence tacit knowledge. Tacit knowledge is that knowledge where the ‘owner’ is not fully aware of it and finds it difficult or impossible to articulate in written form. Based on interview feedback, the majority of the respondents also indicated that skill is an essential factor that could affect the integration of construction knowledge. An issue related to the lack of skill such as poor workmanship and incompetent construction workers were described as a real challenge in integrating construction knowledge. This is mainly due to insufficient guidance and training of the workers. Other causes of lack of skill advice were drawing inaccuracy and drawings that did not integrate information provided by the designer. In respect of the potential for construction knowledge improvement, the respondents suggested the provision of effective supervision and sufficient training of construction workers would overcome the major cause of lack of skill specified above.

The fourth factor revealed from the interviews relates to staff commitment. The study found that half of the respondents were concerned about poor commitment of the staff as a reason to influence construction knowledge integration. Most of the interviewees believe that poor feedback, inconsistency in decision making and lack of trust have a significant impact on the success of knowledge transfer processes. This study further found that the staff from the public sector and the staff from the consultant company were considered to have often delivered poor service to the construction company staff. A majority of the respondents claimed that a delay in processing contract documents and confirmation for any construction task appeared to be the reasons associated with poor commitment of staff.

The final factor key contribution in influencing construction knowledge integration is monitoring and supervision. Based on the interview feedback, a problem related to monitoring could be viewed in a number of situations. Lack of enforcement was accorded the most influence by the respondents followed by insufficient staffing to monitor projects at the construction site. This problem is due to poor supervision work by the staff including rare visits to the construction
site. Table 5 illustrates critical factors in construction knowledge integration perceive by the interviewees in the Malaysian construction sector.

Table 5 – Critical factors influencing construction knowledge integration

<table>
<thead>
<tr>
<th>Factor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondent 1</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Respondent 2</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent 3</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Respondent 4</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Respondent 5</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Respondent 6</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent 7</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Respondent 8</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Respondent 9</td>
<td>√</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Respondent 10</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Respondent 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent 12</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent 13</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: 1-Lack of attitude, 2-Communication Problem, 3-Lack of skilled, 4- Poor Commitment, 5- Monitoring Problem.

Section B: information barriers

The second objective of the interview survey was to identify key factors that contribute to the information barriers in the Malaysian construction industry. The investigation of the factors that create information barriers highlighted four critical issues including difficulty accessing information; poor delivery of information, non-updating of information and lack of publication were identified as key concerns for this barrier.

This study found that majority of respondents faced difficulty accessing information from various agencies in the public and private organizations such as Public Works Department (PWD), Construction Industry Development Board (CIDB), Local Council, Standard Institute of Research and Innovation Malaysia (SIRIM), Professional Institution such as Architect Association Malaysia (PAM), Board of Architect (LAM), Board of Engineer and Board of Quantity Surveyor Malaysia etc.
The interviewees indicated that most of these agencies have treated information as a highly private and confidential resource to access. Important information such as the building cost index is very difficult to obtain. Restrictions on searching information through agency websites; public and private bodies could also contribute for this barrier. However, most of the interviewees agreed the online information is very important for the industry practitioners. The government was advised to improve on IT facilities including updating information on the corporate website by providing useful information connected to the construction sector such as new products; technology or any other matters related to information respectively.

Ishikawa et al. (1999) mentioned that information is a mechanism to improve performance. However, failure to transfer this information diligently could result in great challenges to integrate construction knowledge. According to the respondents 1, 5, 9 and 13, a second barrier to transfer effective information is caused by poor delivery of information in the industry. The sole factor creating this barrier is due to poor service delivery by the agencies including lack of cooperation and service obstruction by the public and private agency staff. To use information effectively, construction players must be able to find what they need in a convenient and recoverable manner. Therefore, the participants have suggested that through an effective service delivery offered by both agencies, it could provide a better information transfer for the industry.
The third critical issue of information distribution is to deliver updated information to the construction actors in industry. The majority of the respondents claimed that they were not correctly informed of any updates of information including new policies or new guidelines by the public and private agencies. For an example, the latest research findings in relation to construction techniques and products from research agencies such as SIRIM and CREAM, are not successfully delivered to the industry practitioners. Therefore it is suggested for these agencies to provide a platform that could encourage practitioners to receive information related to the industry.

The fourth barrier to distributing information raised by the respondents is the lack of relevant publications in the industry. Only one respondent mentioned that knowledge could be acquired through reading. However, shortages of publications such as newsletters, government information and bulletins, hinders industry practitioners increased knowledge. Updates from agencies such as CIDB could also assist. Thus, the public and private agencies need to enhance their role by producing information through ongoing publications. Table 7 summarises the interview outcomes for knowledge integration perceived by the industry practitioners in Malaysia.

**MODEL FRAMEWORK FOR CONSTRUCTION KNOWLEDGE INTEGRATION**

Knowledge transfer is increasingly seen as an important approach to improve construction performance and it has received considerable attention in recent years. Over the last couple of decades, there has been considerable interest in the application of knowledge transfer in construction. This interest is reflected in the literature, where knowledge transfer addresses social capital in construction project management (Manu and Walker 2006), knowledge creation and learning organizations (Eliufoo, 2005), communities of practice (Ruikar et al. 2009) and technology transfer (Li Hua, 2009). However, there have been few attempts to provide recommendations to improve knowledge transfer practice for construction knowledge integration.
Table 7 – Summary of interview outcomes

<table>
<thead>
<tr>
<th>Themes</th>
<th>Critical Factors</th>
<th>Sub-components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Integration</td>
<td>Poor attitude</td>
<td>Poor feedback, delay confirmation</td>
</tr>
<tr>
<td></td>
<td>Communication problem</td>
<td>Lack of informal discussion, lack of involvement in early stages of design, poor understanding of documents and work procedure</td>
</tr>
<tr>
<td></td>
<td>Lack of skill</td>
<td>Poor workmanship, incompetent construction workers, insufficient guidance and training</td>
</tr>
<tr>
<td></td>
<td>Poor commitment</td>
<td>Poor feedback, inconsistency in decision making, lack of trust, poor service by the staff</td>
</tr>
<tr>
<td></td>
<td>Monitoring problem</td>
<td>Lack of enforcement, insufficient staff to supervise work</td>
</tr>
<tr>
<td>Information Barriers</td>
<td>Accessibility of information</td>
<td>Information is treated as highly confidential, restrictions on online agency website searches</td>
</tr>
<tr>
<td></td>
<td>Poor service delivery</td>
<td>Lack of cooperation, poor service offer by the staff</td>
</tr>
<tr>
<td></td>
<td>Non-updating of information</td>
<td>Lack of information informing of policy changes</td>
</tr>
<tr>
<td></td>
<td>Lack of publications</td>
<td>Short of publication such as newsletter and government information related to new policy and guideline</td>
</tr>
</tbody>
</table>

In an attempt to improve knowledge in the construction industry, various mechanisms have been adopted and discarded by industry-based organisations and government organisations. This paper suggests that what is required are better linkages between the four factors considered to influence constructability - The elements of ‘Control’, ‘Innovation’, ‘Best Practice Guidance’ and ‘Audit’, illustrated for Malaysia (Figure 1).

Loh (2007), from investigating knowledge sharing, has suggested that the aim of the transfer process is for the right information, within the right context, to reach the right person at the right time for the right purpose. Therefore, for construction knowledge transfer and integration, the first strategy of this model proposes that good multi-way communication channels should be encouraged between construction ‘actors’ and the information providers, such as local authority agencies, research bodies and other institutions. This could be achieved through more effective interaction and socialization by the construction community. One of the reasons why constructability issues recur is due to poor decision making and communication breakdown. Brackertz and Kenley (2001) identify that there were no suitable communication channels and processes between authorities and other agencies. This justifies the proposed need for good multi-way communication.
The second strategy that could be adopted to integrate construction knowledge is through the effective distribution of information from research agencies. Research bodies such as the Standards and Industrial Research Institute of Malaysia (SIRIM) in Malaysia provide a wide range of research information. However, effective dissemination relies on information reaching the developer or builder on site. In an attempt to improve constructability, it is important to review current policy and to encourage contractors’ involvement. Short briefing notes or training days could facilitate more effective transference of knowledge.

In the best practice element, integration of construction knowledge is proposed through conducting workshops or seminars and best practice notes. Government initiatives such
as these are intended to encourage the industry to apply proper building practice. Attendance at seminars and workshops could be a mandatory condition to renew builders’ licences and could be a significant way of updating skills and knowledge. The concept of Continuous Professional Development (CPD) could also be extended to construction actors and not be limited to professionals such as architects, surveyors and engineers. These approaches could increase builder’s awareness of useful information from research organisations.

Finally, construction knowledge could be improved through an effective knowledge transfer through auditing. Benchmarking and setting Key Performance Indicators (KPI’s) can monitor the performance of organisations and the construction projects. However simply conducting audits for benchmarking does not of itself educate people within an organisation. Motivation to improve and to surpass benchmarks can be useful to organisations wishing to stay ahead of their competition. Rewards and recognition can be a way to motivate people within organizations (Zaidi and Davies, 2010). Introducing reward and incentives schemes can facilitate motivational achievement in project teams and increase organisation performance (Hartmann, 2006; Grisham and Walker, 2006).

In order to achieve successful integration for the above model, a basic strategy map (figure 2) for knowledge transfer is recommended in encouraging information transfer for control, innovation, best practice and audit elements (Figure 1 above). Critical factors identified through the interviews that include attitude, communication, skills, commitment and monitoring need to be improved. These factors for improvement are then referred to on Figure 2 as strategy map 1. Strategy map 2 lists factors relating to the information barriers, including difficulty in accessing information, poor service delivery, inadequate updating of information and publications that also need to be enhanced. These are explained further below:

- **Strategy Map 1.** Knowledge could be integrated through sharing of information among industry practitioners during the construction process. For an example, the need for improved workmanship and skills can be achieved if information is fully created and organized among industry practitioners and knowledge providers. This requires better communication platforms by considering a good commitment from staff in both public and private agencies. Whilst for the knowledge provider agencies, monitoring can be improved through an effective enforcement and supervision process. The requirement to provide training is suggested as one of the solutions in handling information transfer.

- **Strategy Map 2.** Construction knowledge can be integrated through an improving of the information networks from the knowledge provider agencies. This requires a drastic change of the system that delivers information to the industry
practitioners including the improvement of service delivery; providing effective accessibility to browse information, update information regularly and improved publication are recommended as an approach to integrate construction knowledge in industry. Through this, information can be successful delivered to the industry practitioners. Figure 2 shows the recommendations for knowledge transfer in integrating construction knowledge.

**Figure 2 – Knowledge map strategy**

CONCLUSIONS
Knowledge can be integrated and optimized through successful transfer of information. The need to upgrade and improve knowledge transfer approaches will facilitate and enhance building performance throughout its lifetime, by educating everyone involved in the construction development process. The practices adopted in Malaysia for knowledge transfer development intended to improve construction knowledge integration have been reviewed and mapped against a model of improved information transfer.

Based on the current issues in construction industry, an analysis of current literature and survey interview on the perception of knowledge transfer applied in the Malaysian construction industry, this paper suggests the following:

i. The need to improve communication and interaction between information providers and parties involved in the construction process should be the first priority to be considered for the success of construction knowledge transfer.

ii. Construction companies and information providers must engage to ensure information transfer systems are set up that are effective thus achieving the goals of improved building quality.
In conclusion, the implementation of better knowledge transfer mechanisms through an effective information distribution strategy is likely to improve construction knowledge. Finally, creating a knowledge chain among the four elements (control, innovation, appraisal, audit) of the proposed model could initiate continuous improvement in the construction industry.

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