

“Information sharing problems among stakeholders in the construction industry at the inspection stage: A case study”

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Abstract

The paper reports the information management practices of the various key stakeholders during the inspection stage of a construction project. The data was collected through observations and shadowing of stakeholder exemplars, interviews and document analysis over a fourteen-week period. In the process of constructing a new and innovative academic building for an Australian University, vast amounts of information had to be effectively managed by various stakeholders in the construction process. This life cycle includes the creation, documentation, dissemination, utilisation, evaluation and archiving of the relevant information and knowledge across multiple domains and areas of practice and expertise. Without efficiency in these processes the effectiveness of construction project outcomes and contractual obligations could be challenged. This research evaluates the information life cycle through an Information Audit (IA) in the inspection stage of a large-scale construction project (the innovative academic building) through an evaluative lens integrating the concepts of Enterprise Content Management and Personal Information Management. The research shows that information auditing enables framework identification of iterative and problematic information reporting in the Construction process. The research shows the pivotal role of a key stakeholder involved in the process acting as an intermediary, translating and transferring information across different domains.

Keywords: Construction Inspection, Information Sharing, Information Audit, Information management, defects recording methods.

1. Introduction

The paper reports the information management practices of the various key stakeholders during the inspection stage of a construction project. The data was collected through a series of observations and shadowing of stakeholder exemplars, interviews and document analysis over an intensive fourteen-week period. In the process of constructing a new and innovative academic building for an Australian University, vast amounts of information had to be effectively managed by various stakeholders in the construction process through the use of an information life cycle (Persson, Malmgren, & Johnsson, 2009; Wenfa, 2008). This life

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cycle includes: the creation, documentation, dissemination, utilisation, evaluation and archiving of the relevant information and knowledge across multiple domains and areas of practice and expertise. Without efficiency in these processes the effectiveness of construction project outcomes and contractual obligations could be challenged. This research evaluates the information life cycle in the inspection stage of a large-scale construction project (the innovative academic building) through an evaluative lens integrating the concepts of Enterprise Content Management and Personal Information Management.

In all sorts of projects, including construction, the way people categorise documents is very personalised and most often linked to experience and domain knowledge. Both of these factors influence how we use information and this changes over time and from project to project (Arnorsson, 2012; Peansupap & Walker, 2006). This research clearly demonstrates how each of the stakeholders in the construction inspection phase process made use of differential means of collecting, storing and using their personalised information. An Enterprise Content Management System (ECM) managed the overall project, however, access to this was only for one set of stakeholders, the architects, and they admitted they rarely used it as it was seen as a repository rather than a system to manage active documents. Some stakeholders in this project made use of electronic devices such as tablets, whilst others relied on hand written notes. The project architects and some of the builder supervisors used annotations on plans and drawings. While the Principal Architect took minimal notes but, instead, relied on expertise in the domain and experience (Bartholomew, 2008; Cavieres, Gentry, & Al-Haddad, 2011) with the project from the beginning. Throughout the project, each of the stakeholders interacted with their Personal Information Management (PIM) systems to collectively create the construction process. In this construction project the outcomes were successful because of the key roles played by the Principal Architect and the Site Architects. Their combination of technology, memory and experience provided the substance for maintaining all of the requirements that needed to be completed during the inspection stage. At times, this process was confronting and argumentative as the personalised collections of information from each stakeholder's perspective was often different. Ultimately the 'memory' or 'tacit knowledge' of the Principal architect and the drawings agreed upon formed the basis of all decisions and the means to achieve all the requirements of inspection.

2. Research Context

2.1 Construction Process

The construction process is complex and contains vast number of sub-processes. The construction process is one where all stakeholders involved bring about their resources to put together the building/project and complete it within an agreed timeframe (Andrew et al 2006). The stakeholders in the construction process include clients, project managers, architects, consulting engineers, builders, contractors and sub-contractors, suppliers and users. The construction process can be viewed from different points of view and often can be explained differently. For example, from a business point of view the construction process includes a business case, conceptual designs, detailed designs, bidding preparations, bidding, awarding of contracts, build, handover and operations (Chinyio & Olomolaiye 2010).

The design process itself also contains large amounts of sub-processes such as requirements gathering, calculations, design layout and specifications determination. From the builder's point of view, the construction process includes pre-construction, shop drawing reviews, site setout marking, build, inspections and rectification. To enable a simplified example of the role of information auditing and tracking in the construction process, this study will focus only on the inspection stage during the build process.

The construction process is fragmented and differentiated via stakeholder role and the multiplicity of processes involved. These depend on the types of project delivery systems in use and notions of contracting (Chinyio & Olomolaiye 2010). Furthermore, the role of stakeholders involved and the scope of works in the construction process also vary as a result of the type of project delivery systems in place (Marco, 2011). The construction inspection phase is a process in which stakeholders carry out checking procedures to ensure that the building that is being constructed meets the project requirements (Ricketts 2001). These requirements include designs, specifications, contracts, documents, appearance, building codes, functionalities and happens within the agreed timeframe. The inspection process requires specific benchmarking or checklists that each stakeholder needs to inspect the building against. This benchmarking and checklists form part of the information captured as essential and needed for the project. This information has to be carefully managed to enable integration of the complex parts of the construction process. Much of the information is tacit (Shelbourn et al 2006, Tuuli et al 2010) and held within the domains of the various stakeholders.

2.2 Information embedded in the stage, stakeholders involved and the role of sharing

Information sharing is the process of exchanging information between two or more people (Ford & Staples 2010; Ling, Sandhu & Jain 2008). Information sharing is a process, in which an individual passes on their information. These include both tacit and explicit information (Ford & Staples 2010). This information includes both existing information and new information generated within information sharing processes. Most of the time this happens while employees or experts with domain knowledge in organizations are doing something together (Lilleoere & Hansen 2011; Lindsey 2006). Information sharing is important, as research has shown that it can be used to create competitive advantage for the organisation (Bryant 2005; Grant 1996; Porter 1993).

However, there are factors that impact the efficiency of information sharing. There include an individual's absorptive capacity (Reilly & Sharkey 2010) for additional or new information. Individual absorptive capacity is an ability of an individual to interpret received information and utilise it and turn in to action (Lilleoere & Hansen 2011). Nonaka (1994) mentions that to share tacit knowledge/information in the organization requires social interaction between an individual through human activity. Individuals in the group or in a "self-organizing team" perform this activity. The purpose of these activities is to pursue new problems and solutions. This interaction group can be within the organization or among individual formed inside and outside the organization (Nonaka 1994). Nonaka has listed factors that contribute to the success of information sharing. These are trust among individuals in the group, and

the existence of a common perspective that each individual has towards the group and towards dialog or individual communications. Holste and Fields (2010) have studied trust in information sharing in an international organization. The research found that warm relationships and respect are most likely to develop through face-to-face interaction among workers. This relationship among workers or trust has affected willingness to share tacit information. Van den Hooff and Huysman (2009) have found that organizational culture has an effect in organizational information sharing, the more interaction of employees in an organization, the higher the trust (Van den Hooff & Huysman 2009).

Kanjanabootra (2011) showed in a manufacturing construction process context that a process of information sharing could integrate multiple stakeholders in the process. In that research the catalyst was an external engineer with domain expertise in the process involved. The role of that engineer was to create a common language for the stakeholders to understand and enable the sharing process so that all understood all information elements of the project. This was collected and stored in an information system, which was made accessible to everyone in construction the role of catalyst, is often the project manager. However there are a multiplicity of domain expertise elements across all of the stakeholders and in construction the complexity of the tasks (Pan, Gibb, & Dainty, 2007) means that often not all elements of information understanding and completely understood by all stakeholders. One of the ways this might be overcome is the use of IT and an ontological-based structure to facilitate effective information sharing. One model that can be used to enable this is the use of the information life-cycle concept.

2.3 Information lifecycle

One of the most valuable assets an organisation can possess is its information. The ability to use it correctly and effectively may allow an organisation to gain insight to what is happening as well as, in many instances, speed up existing processes. This is no different within the construction industry. (Han, 2010)

Information within an organisation follows a lifecycle. Many have attempted create and define what is involved within an information life cycle, including the activities and processes. However, what is known is that many of these models represent anywhere between three to seven stages. At it's most basic level an information lifecycle will include: creation, dissemination, storage and disposal. The information lifecycle was selected and made use of in this particular project as it provided the researchers an evaluative lens in order to understand how information is made use of through the final inspection stage of a construction project.

2.4 Enterprise Content Management Systems

In recent times, we have seen a push towards Enterprise Content Management (ECM) within organisations. It has been successfully applied in many industries such as pharmaceuticals, finance and aviation. The use of ECM has allowed these industries to manage and integrate their structured, semi-structured and unstructured data in a meaningful way (Päivärinta & Munkvold 2005). Studies have also indicated that there is an

increasing amount of unstructured data being created and stored within organisations, with unstructured data accounting for 90 percent of all information created and stored (Jenkins, Glazier & Schaper 2004).

With the sheer abundance of this unstructured data, and the increasing amount of complex projects that organisations within the construction industry are faced with, many are finding it a real challenge to deal with all this information. Rogalski states that for an organisation to achieve high performance they should have in place an effective information management plan as well as taking into account other factors such as: the increase in data management cost, the difficulty of finding the right information and making use of information that has already been collected to yield useful new insights. Rogalski then also goes on and suggests that in order to solve these problems, many businesses and organisations are turning to ECM as it has the potential to streamline their business processes and increase collaboration within an organisation (2006).

3. The project case study

Although from the conception to practical completion of this multi-million dollar innovative academic building for a prominent Australian university took just a little over four years, this particular research project ran for a period of fourteen weeks.

Preliminary interviews showed that the case study project has unique characteristics when compared to total gross area within the construction time scale. The project was a challenging one because large amount of defects were both generated and handled during construction stage. "We found that there were fifteen something thousand preliminary defects found and in total over fifteen thousand defects generated for the whole building" said one research participant. The interest in this research was to investigate how the project team carried out such a complex and fast tracked project and managed to finish it within the time frame.

It investigated how various stakeholders in particular; architects (of which there were two) and builders (of which there were three) managed the information that was being produced during the inspection stage of a construction process. It studied the information management practices of the organisations in which the stakeholders were employed, their individual information management preferences and practices as well as the tools and technologies that were involved in successfully completing this task. In total, a Gross Floor Area (GFA) of 35,000 square meters, which totaled of eleven storeys, was checked for defects. Data was collected via various techniques, which included: observing, shadowing and interviewing the stakeholder participants.

4. Research Method

This research was developed in an interpretivist framework through the researchers using observation and shadowing of stakeholders involved in the inspection process of the single case construction project being studied. Yin (1994) has defined case study research as one which 'investigates a contemporary phenomena within its real-life context, especially when

the boundaries between phenomena and context are not clearly evident' (Yin 1994, p. 13). Both Yin (1994) and Eisenhardt (1989) also suggested that a case study is a good technique to use to study social phenomena in a single setting. It can help researchers answer 'how' and 'why' questions in the situation that involves social behaviour through exploratory, descriptive or explanatory research (Barkley 2006; Blaxter, Hughes & Tight 2006; Eisenhardt 1989; Rowley 2002; Stake 1978, 1985, 1995; Yin 1994). The researchers also interviewed the stakeholders to try and understand not only the processes they were engaged in but also to try and understand how they collected information, how they stored information and organized it and how they shared and used this information during the inspection phase.

Qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Creswell 1997; Denzin 1994). Morgan and Smircich (1980) argued that the choice of research methods had to evolve out of the context of the research, not out of abstract reasoning (Morgan & Smircich 1980). The context of this research is embedded in the intricate interplay of numerous ways the various stakeholders in the construction project involved interacted with each other, with executives, with clients and with the design/build and testing process they were using on a daily basis. These interactions created a very complex environment where the adoption of simple tools of research would have produced little of any value. There was a need to address all of the processes in multiple ways to ensure that all of the detail in and nuances of, the data, information and knowledge were captured accurately. In this way, the researcher becomes much more experienced with the context of their research. The researchers were able to justify their understandings based on the detail of their observations, discussions and interviews. In this research, that complexity was addressed by the use of multiple qualitative research methods and techniques. Despite the increase in mixed method approaches (Mingers 2001), it is unusual for qualitative methods to be used in combination with each other (Frost et al. 2010). This is often a problem because of the multiple ideologies often embraced by qualitative researchers.

The researcher's perspective, in essence his own domain knowledge, can also play a key role in qualitative data analysis and the extent to which generalizations can be made. However, they are rarely undertaken as part of the one research project. Certainly, comparisons are being attempted within, (Frost et al. 2010) but those comparisons assume that each method is informed by different ideologies. In this research, the same interpretive structure (Walsham 1995) – based on the one researcher's domain knowledge and technical expertise in construction and the others in information sharing and auditing – forms the unifying framework through using a single interpretive case study, as a means of understanding the inspection process story. The research process involved an iterative set of interviews, discussions and observations of all stakeholders involved in the inspection phase of the academic building project. Each iteration involved feedback, re-discussion of observations and re-questioning of the participants to check observations and conclusions of the researchers throughout the process. The data collected was interpreted through a hermeneutic lens of feedback, interpretation, observation, interpretation and re-interpretation, leading to sets of conclusions.

5. Research Outcomes

This case study of a major construction project for education purposes has highlighted a number of conclusions that add to knowledge about information use, sharing and storage in the inspection phase of construction projects. Each of the outcomes derived from the analysis highlights issues that relate to process, issues that relate to domain knowledge problems, issues that potentially could derail the effectiveness of this part of the construction process.

5.1 Multiple stakeholder roles, which were not clearly defined

During the observations the researcher found that the role of the different stakeholders during the inspection stage was not clearly defined. In all, there were two stakeholders involved during the inspection process: the architects and builders. It was observed that it was mainly the Architect who primarily led the inspection process, whilst the builders took on a secondary role of recording the defects. However, these roles could switch depending on the situation and room they were in. On a number of occasions the defect list that both stakeholders made are out of alignment. Some defects appeared on the architect's defect list but have not been noted on the builder list and vice versa. The observations also showed that contractor who responsible for rectify the defects were excluded from the inspection process. In this project it was builder who had to transfer all of the defect details that they noted during the inspection process to the contractors.

5.2 Differences in access and availability of information management tools

The builder involved in this study made use of an in-house IT support tool to manage their information during the inspection process. The tool mentioned is a tablet computer, which ran a spreadsheet-like application. The inspector engineer who carries out the inspection process can select the inspection area (room number) and enter the defects details into the application. On many occasions there were multiple defects occurring in a single area. The engineer often had to add additional information into the system in order to distinguish the differences between them. Additional information often included; directional side of the room (west facing wall...) and take photos of those defects. However, the photo files and the tablet application were not integrated. The inspector engineer then had to sync and transfer details regarding the defects and photos onto the desktop computer located in the site office for internal documentation and to circulate to architect and contractors for further actions. However, the architects and contractors in this study did not have access to the same IT supporting tool as the builder. There were a number of occasions in which the defect lists were distributed to contractors so that they were able to rectify the defects, however; the contractor could not find the actual defects onsite due to the way the of the defect was described. As a consequence, the builders had to physically head onto site and point to the defects contractors.

5.3 Multiple methods of information recording, coding and storage

Throughout the inspection stage of this project there were multiple forms of information being recorded and stored. Different methods, criteria and tools were applied. For example, Architect A used the specifications and drawings to check issues during the inspection; whilst Architect B from the same company, relied on their tacit knowledge and expertise and did not record any information physically. In terms of process, the Architect A took pictures, wrote notes, and did drawings on paper and upon returning to the company's office he recoded all the information in the company's information systems and filled out the appropriate internal paperwork Whilst Architect B did not record either onsite or in the office. He verbally expressed the information and made sure that others were taken detailed notes. In shadowing Architect B in subsequent sessions in the inspection process, he demonstrated his use of memory and recall of issues without reference to stored or organised information. In terms of sense making Architect A made use visual representation through photographs. Architect B used memory and domain expertise for sense making.

5.4 Information incompleteness

It was observed that information gathering within the inspection phase of this project was invariably not systematic and happened in an 'ad hoc' manner. Stakeholders involved with these inspections would often switch from one space to another without adhering to the agreed plans. This was mainly due to the fact that, construction workers who were working on other aspects of the building, required instant clarification on certain issues in order to continue on with their tasks. This often distracted the builders and architects away from their primary duties and, in turn, meant that additional inspection times were required to be scheduled around their already busy work schedules. Another example of how information being collected in an ad-hoc manner included stakeholders switching the format in which they collected the data. One moment they would be noting the defects down the tablet and the next make use of pen and pad. After further clarification with the stakeholders, this was attributed to the amount of time available to them. The stakeholders stated that there was 'too much time spent wasted recording notes on the tablet versus hand written notes'.

5.5 Information gathering happens in an 'ac-hoc' manner

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attributed to the amount of time available to them. The stakeholders stated that there was 'too much time spent wasted recording notes on the tablet versus hand written notes'.

5.6 Shorten project timeline

The construction schedule is a very important element in construction project. The schedule determines the timeline for the building to be being constructed then and inspected for defects. For example, the project manager and construction manager needed to coordinate with contactors need to carry out their work to get material and workforce into the construction site in such an order to maximize construction workflow. In a 'Design and Build' type of contract especially as in this project the builder was offer an intensive program to finish the construction process as fast as they could. In the construction industry, it is not only the financial intensives that drive a builder to finish the project ahead of the schedule however, to finish the project ahead of time will also provides a good impression on their clients which, could, eventually assist the builder in winning additional projects.

Another observed factor, which contributed to the reduced timeline in this project, was the scheduling of multiple inspections at the same time. Both the builders and architects understood the importance of the timeframe in which they had to operate in, hence additional staff, were allocated so that defects list could be sent out to contractors to rectify their defects sooner.

5.7 Differences in: background, knowledge and experiences of participants

The research established that during the inspection process stakeholder's experience, knowledge and backgrounds were also having impacts on the inspection process. There were a number of occasions when the architect spotted a defect and the rectification has been requested. However, the architect's rectification request was not practical in a builder's perspective. The builder offered an alternative solution that was often more practical, cost effective and still met the architect's requirements. Sometimes the architect identified the defects to the builder. However, due to some physical characteristics of the equipment that limited their further actions. Therefore, both stakeholders had to come up with compromised solutions. On the other hand, one of the builders involved in the inspection process is also a qualified architect. This builder was able to understand the defect from an architectural and design perspective better than the other builders who have had limited or no architectural background. During the observations the researcher found that experience is a crucial elements for both architects and builders to come up with the solution to the spotted defects. Sometime both stakeholders have to delay the outcomes and seek further advice from their supervisors back at their respective offices.

6. Discussions

After the examination of the data collected through observations and shadowing of stakeholder exemplars, interviews and document analysis over a fourteen-week period, the figure below outlines the causes of information sharing problems that the stakeholders faced whilst attempting to conduct the final inspections for a construction project.

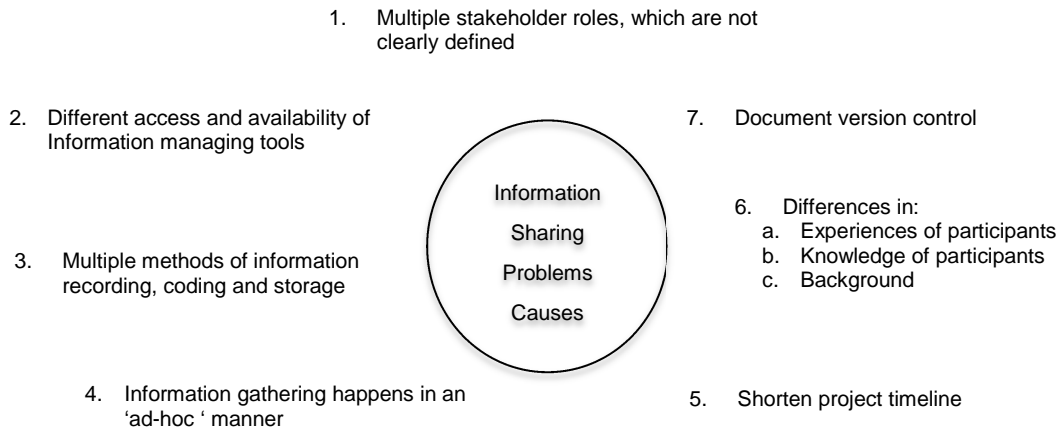


Figure 1: The causes of information sharing problems

The research shows that the various stakeholders involved made decisions and undertook their roles in the inspection process utilizing their differentiated knowledge domains. Ordinarily the interaction of differentiated knowledge domains results in poor decision-making and often leads to ineffective project management and sometimes project failure. In this project that potential for incompleteness was compounded by the multiplicity of methods used throughout the inspection processes. Use of different personal information management systems and different and incompatible technologies by each stakeholder, and the lack of attention of a project information management system created the conditions for significant failure. However the project was a success. The research showed that the solution only happened because of one key stakeholder, the Principal Architect, acting as an intermediary offering sense making of each knowledge domain across all other stakeholders. Information flows and information sharing centered on the pivotal role the architect played. He became both the conduit and interpreter of the existing differential knowledge and enable project success.

The information lifecycle tool used in the analysis of the case study data revealed that although all the stakeholders were working towards the same goal, they did so by making use of the information presented to each one of them differently. Each made sense of the situation through their own experiences, their organisation's restrictions and policies, the tools and technologies available as well as their own personal preferences. It also offered another evaluative lens to understanding the importance of information in the construction process and offers project managers and stakeholder-managers of construction projects a means to foreshadow information-sharing problems that may inhibit the effectiveness of projects. Information auditing as used here exposes inefficiencies and highlights iterative cycles in practice, differential levels of information sharing and information asymmetries, all of which can affect the efficiency of the construction process.

In conclusion, the findings of this study seem to indicate that there were a few lessons that the stakeholders in the construction industry needed to learn from each other. These included: the need to increase the effectiveness of information management practices during the inspection stages and the need to clearly define the roles and responsibilities for each stakeholder from the outset. Having a greater understanding of these lessons may facilitate a decrease in the number of defects and re-work that often occur in every construction

project. If the amount of re-work in construction projects can be reduced or eliminated, then the construction process effectiveness then can then be improved.

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