Assessing organizational semiotics for IT systems design: improving information exchange processes across construction project stakeholders

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ABSTRACT: Construction projects are information-intensive collaborations between diverse collections of stakeholders and organisations. A recurring challenge for IT systems designers is to produce solutions better able to engage with the diverse informational requirements of varied construction industry professionals engaged on a construction project. This paper explores how organizational semiotics (OS) may be utilized in a construction project context in order to explore information exchange problems & issues prevalent in the domain. Organizational semiotics (OS) is the study of sign generation, exchange and interpretation in organizational contexts. It examines and explores how people and technologies interact and work together in the pursuit of business goals. OS tools may be used to develop and model IT systems which have a conceptual grounding in both technical (data-flow) and humanistic (behaviour) principles. We explore the potential of OS for developing new IT tools to mediate heterogeneous activities of information production and exchange across diverse stakeholders.

1 INTRODUCTION

Construction projects have long been characterized by sub-optimal information exchange processes amongst the various building project stakeholders. The reasons and consequences of such occurrences have been well documented in the literature (Higgin & Jessop, 1965; Egan, 1998; Love et.al, 1999; Miozzo & Ivory, 2000; Harty, 2005; Zietsman, 2008). Whilst information technology (IT) applications have eased the life of a multitude of professionals engaged in the construction industry, the development of an IT tool which facilitates information sharing across and between the various stakeholders engaged in the entire "through-life" of a construction project has yet to be achieved.

This paper describes an emerging theoretical field - organizational semiotics (OS) - as holding the potential to lay the foundation for the creation of new tools to support the information exchange processes experienced on any construction project. An OS oriented analysis of construction activity may provide valuable insight into the very real and highly complex social relationships existing between project actors and organizations which occurring on a day-to-day basis and underpin the exchange of information across a project.

The paper begins by reviewing the status of existing IT application and use in the construction sector. We argue that although IT tools and their utilization is highly sophisticated within construction, such technologies and practices are in the main bounded within single organizations, rather than spreading across the inter-organizational landscape of construction work. We then discuss the role of information on construction projects, and approaches to its conceptualization, and we emphasize the need to consider social and human oriented aspects of information and information exchange, as well as technical aspects (such as structure and typology). We use this to introduce the philosophical foundation of organizational semiotics, which involves considering the way that signs (any piece of information or representation) are produced and interpreted – a process of 'semiosis'. We go on to outline some of the ways OS has been mobilized methodologically to assist in the elucidation of a problem and make user requirements more distinct. We especially draw on the Norm Analysis Method (NAM), derived from the MEASUR research programme (Stamper et al., 1988).

To assess the usefulness of these techniques, and that of the OS theory more broadly, we outline some examples, and discuss empirical material from an on-going research project. The project is following the construction of a new £50 million office building in a city centre location – the CC1 project. The em-

pirical material is used to demonstrate some information-oriented processes that are amenable to capture through NAM oriented analysis, and others which although highly relevant to OS and the notion of semiosis, are more challenging to incorporate into these methods. We then conclude by arguing that some processes can be analyzed in terms of current OS methodologies, which could then benefit information systems design utilizing OS principles. But other processes are more difficult to analyze with current techniques, and more research is needed to develop approaches more able to incorporate complex processes of human semiosis. We then outline the dual strands of our on-going and future research. The first is the further development of OS based information systems to support the process of information exchange in construction. The second is the further development of frameworks and approaches to reveal and analyze more complex human-centered semiotic processes.

2 IT IN CONSTRUCTION

The uptake of IT in the construction industry has been characterized by some as slow and piecemeal. Betts (1999) mentions industry fragmentation, the up-front investment required by companies, resistance to change in the workforce, on-going maintenance costs of IT and the low levels of technology awareness in the sector as being foremost amongst the explanations for low levels of IT implementation. Although there is some credence to this view, for the past three decades there has been a great deal of IT adoption, and current construction organisations are very often highly sophisticated users of IT.

The applications themselves continue to rapidly develop to such an extent that a wide range of professional needs are now catered for. These range from CAD applications for designers and engineers, visualisation tools for clients and users, on-site progress monitoring software for site workers, cost evaluation tools for managers, quota management programmes and, increasingly, facility management operations packages.

The utilisation of IT for an increasing variety of functions has been noted by numerous researchers. Examples include visualisation (e.g. Whyte, 2002), the production of coordinated 3D models of projects incorporating multiple disciplines (e.g. Olofsson et al., 2008) for coordinating the construction process (e.g. Harty 2005; 2008), and the combining of a number of technologies to produce information-rich Building Information Models (BIM) (Eastman et al., 2008; Manning & Messner (2008)).

However, there are still some deficiencies. Taking BIM as an example, it has been heralded as having the potential to provide the industry with an all powerful information exchange solution. However, Howell and Batcheler (2005) state that although BIM applications have now reached a high level of sophistication, designers remain the primary users of BIM applications. This they attribute to different disciplines utilizing their own specialized and often non-inter-operable applications for their own professional needs (e.g. building performance modeling (BPM) applications for building energy/ environmental performance).

It is certainly the case that an overwhelming amount of IT tools used within construction are either disciplinary-based (such as Architectural Desktop for architects, and Tekla for structural engineers), organization-specific (such as document management and information management systems) or provide a specific function (such as BPM tools). IT applications which span across disciplines, functions or organizational boundaries have had much less success.

This observation can be seen as an inherent weakness regarding the actual IT packages in the sector: they have reached a high level of sophistication for specific uses, but do not attempt to integrate across these boundaries. But it is also the case that project wide and inter-organisational information systems must take account of a wide range of often conflicting existing practices, expectations and interests. In such an ‘unbounded’ context (Harty, 2008) it becomes difficult for one organisation to exert enough influence over others to enable one particular IT system to be universally adopted.

This perhaps explains why no IT application which truly spans professional divides and organisational boundaries has yet been widely and repeatedly adopted in construction. The challenge of producing information systems which span these boundaries, but which also account for these different backgrounds, expectations and interests of the diverse actors and organisations, remains.

3 CONSTRUCTION PROJECTS

The unique nature of construction projects and the role IT has to play deserves further consideration. As unique and distinctive enterprises, construction projects often bring together stakeholders for the one and only time. Therefore, there is little motivation to explore collaborative information sharing work patterns between the various organisations. Additionally, the strict time and financial restrictions imposed by any project and the fact that each stakeholder will already possess their own sophisticated IT packages mitigates against the exploration and use of new information sharing methods.

Yet, as intensive collaborative exercises, construction projects are redolent with information issues, which might be alleviated by more integrated IT. For example, Gyamph-Vidogah and Moreton

(2003), identify a very real issue regarding information adaptation commonly encountered during construction project work,

"…each functional department maintains its own data to suit its particular needs. As such, using data from other functions requires the data to be reformulated. The absence of adequate interfaces means that in many instances, data on cost items such as materials, equipment and labour have to be extracted from paper records."

The problem of managing and analyzing construction project data due to the diversity of the data sources has also been highlighted by Soibelman et al. (2008). Whilst structured data (usually stored in spreadsheets and relational databases) may be relatively easy to analyze, unstructured sources such as images, web-based and text-based messages may not be as simple to prepare for analysis. The diversity of data produced through the course of a construction project is an obstacle to its` simple analysis. The volume and diversity of information generated during the construction project process and the variety and complexity of stakeholder interactions which occur (both formal and informal) are additional issues which impede the development of methods which effectively deal with the capturing, organisation and reuse of project information and knowledge (Hicks et al., 2002).

One approach to this is to distinguish "high value" data from "low value" data in the context of the through-life building process (i.e. which data will be of interest to multiple stakeholders and which will not be). This issue has been addressed by Zhao et al. (2008) in the context of the development of a prototype data evaluation tool. Both Rezgui (2006) and Mak (2001) argue for the further use of Internet technologies in the construction project information management process and argue that current application of IT is piecemeal, discrete and non-systematic: a wider adoption of Internet technologies would be a platform for enhanced information flow. This is set within the context of the limitations of current IT approaches to managing information and knowledge arising from construction projects. But more importantly, Rezgui (2006) advocates that any potential solution should be human centred, adaptive, supportive to existing practices, open and scalable for easy use, secure and evolutionary.

Research into developing new IT tools for the construction sector have traditionally focused upon efforts to model and simulate information and data flows as a basis from which to develop systems. For example, Baldwin et al. (1999) reported on work to model and simulate information flow at the conceptual and schematic stages of building design (the resulting data being used for further tool/technique developments).

It is true that object-oriented (OO) based methods of IT systems development are now established as the most widely utilized technique within the industry. This fact was recognised by Amor et al. (2002) in a global review of IT research work across the construction sector. However, the importance of recognising the social and organisational realities of business domains within which IT systems may be developed should be paramount. To focus upon technical aspects only may be folly:

"Many information systems methodologies only stress the technological aspects. This may lead to a solution that is not ideal, because the methodologies underestimate the importance and complexity of the human element" (Avison & Fitzgerald, 2006).

Similarly, Gyampoh-Vidogah and Moreton (2003) point out that the challenge for information systems management is how to reconcile human, organizational and technical factors. Hartmann et al. (2009) argue that developers have found it difficult to gain an advanced understanding of the tacit knowledge of AEC professionals when designing applications for their use. Accessing the tacit knowledge of professionals and understanding how professionals communicate and interact has been the subject of much prior research (see e.g. Mohamed and Anumba, 2006), and is critical for the development of effective collaboration supporting IT systems. Hartmann et al. maintain that determining how construction project personnel communicate is largely defined by the roles, norms and values of the professionals which change from project to project during the life-cycle of the project itself. Therefore, an enhanced understanding of local project contexts is necessary.

Such arguments can underpin the development of information systems design methodologies which might more effectively capture the complex and diverse human, social and technical processes occurring on a construction project. Such an approach could help to represent information to each function, discipline or wider stakeholder more effectively.

As construction projects are notoriously complex collaborations where social problems are often the root cause of the difficulties, any approach which seeks to investigate and elucidate such issues is worthy of further investigation. Organizational Semiotics (OS) is one such theoretical approach to information systems development. As Stamper et al. (2000) state,

"Organizational semiotics adopts a "social-subjectivist stance and an agent-in-action ontology".

This effectively means that OS approaches consider both technical and social aspects of IT use, and consider the dynamic processes of information interpretation and exchange. This is quite radically different from many information systems methods which focus on technical rather than social aspects of IT use.

4 ORGANIZATIONAL SEMIOTICS

4.1 *Theoretical foundation*

Semiotics may be defined as "the study of signs" or "the discipline of signs" (Peirce, 1960) and investigates the inception, generation and meaning of signs, encompassing their analysis, interpretation and representation (Liu et al., 2006). OS, a sub-branch of semiotics, is the study of sign generation, exchange and interpretation in organizational contexts. OS may be used to critically examine and explore how people and technologies interact and work together in the pursuit of business goals (through sign generation, interpretation and analysis). OS analysis methods give particular attention to the social influences affecting organizational effectiveness (i.e. the actions and activities of actors and factors affecting such actions). An organisational system may be analysed and modelled through an elucidation of agents and their sign generation/exchange processes. A rigorous investigation of a problem domain utilising OS methods and tools may be used as a basis for the development of IT systems: IT systems which have a conceptual grounding in both technical (data-flow) and humanistic (actions, practices) principles.

The "model-reader" concept (Eco, 1979), has a strong semiotic foundation, and serves as a good example of semiotic processes, or 'semiosis'. This states that the developer or 'author' of a sign must recognise how a specific interpreter or 'model-reader' is likely to understand any generated sign. This means that the more closely aligned the generational and interpretational processes of author and reader are, the greater the likelihood of the sign being interpreted or read as the author intended. This mobilisation of shared pragmatic frameworks between designers and users has been used extensively in computer systems interface design (e.g. icon design, Barr et al., 2004) and in more theoretical discussions. For example, Woolgar (1991) explores how specific artefacts may be designed to directly align with their envisaged use by a user (whilst prohibiting others in the process). From a construction project perspective, an exploration of this theory has validity. For example, an architectural plan will contain data of use for multiple users, but perhaps not in a format that is easily accessible for them all. An OS oriented exploration of such information-artifact usage throughout the construction project process can specifically explore these different requirements, and analyze whether artifacts or interfaces may be better aligned to the different interpretive schemes and pragmatic frameworks of stakeholders.

As an information systems developmental approach, OS is distinguishable from other information systems methods, which focus on "dry" or "hard" aspects such as data-flow movements. It focusses upon the social and organizational factors prevalent in any business domain (Liu, 2000). A thorough and extensive application of tools utilizing OS theories can offer the analyst and system developer the opportunity to develop IT applications which are more attuned to the complex organizational, human and technical interactions commonly encountered within any business setting. A construction project - a highly complex, information-intensive collaborative venture between multiple stakeholders - provides a relevant context to explore and apply such theories and tools. As de Souza et al. (2001) maintain,

"The rules which software must abide to are only those relative to formal symbol processing and computability. But the relations by which symbols gain meaning to programmers and users alike are in the minds of the beholders, outside the reach of algorithms and data structures….designing software is thus close to writing about what one perceives as being the case".

An example from construction is useful to highlight this idea that semiosis extends beyond the artifact and is dependent on the individual. Take a site-worker who is given five separate documents, each of which details certain information useful for her job. On site, the worker can't practically refer to five documents, and so uses her experience and knowledge to translate the relevant information from all five onto a single document. The creation of such a referential document can only be achieved following a careful investigation into the site-worker`s personal understanding, interpretative and assimilation processes. What processes does the site-worker go through before a subsequent action based upon the data received can begin? Similarly, a majority of projects now use a shared online database as a repository for project data for multiple stakeholder access and utilization. But stakeholders often encounter problems identifying what they need from such shared repositories as the content has not been aligned to their particular needs. Can such databases be aligned to the interpretive audiences accessing them? Such theoretical questions may be investigated via an analysis of the activities of agents (e.g. site-workers) in relation to their work and the organizational setting within which they find themselves. OS methods can help in approaching such questions.

4.2 *MEASUR*

Initiated in the late 1970s by Ronald Stamper (Liu, 2000), the MEASUR (Methods for eliciting, analysing and specifying user requirements) research programme aims at the development of a set of methods for the development, management and use of information systems. Grounded in organisational semiotics theories and principles, MEASUR has now led to a set of research analysis tools which can be used to examine a problem domain and then derive a set of solutions for the scenario being considered.

MEASUR methods can be applied to all stages of the systems development life-cycle, from infrastructure analysis and requirement analysis to construction and audit (Liu, 2000). The methods themselves may be combined with other techniques at any point (e.g. a fourth-generation language or an object-oriented language may be adopted at the implementation stage of a project).

MEASUR methods allow an entire organisation (including both human and IT systems) to be scrutinized and described before focusing and elucidating upon the processes and practices of actors in the domain being studied. A clear description of user requirements is enabled through a description of agents and their intended patterns of activity in terms of social norms (Liu, 2000). IT systems may eventually be mobilized based upon and using the evidence gathered from employment of the MEASUR methods. As an information systems development methodology, MEASUR is a holistic approach which does not just focus upon the information flow aspects of any existing (or potential) system. Brief descriptions of the principal MEASUR methods and tools follow together with a selective demonstration of how such tools may be used within a construction project context.

The Problem Articulation Method (PAM) consists of a set of separate tools which can be used in the initial stages of a system development process to assist in the definition of a problem domain through identification of stakeholders and their interests. A clearer graphical depiction of the problem domain being investigated may also be mapped out using appropriate PAM tools. Kolkman (1993) described 5 separate phases of PAM: Unit System Definition; Valuation Framing; Collateral Analysis; System Morphology and Stakeholder Identification.

The Semantic Analysis Method (SAM) allows a representation of affordances and agents within a domain to be modeled, resulting in a semantic model. This is a clear, precise representation of reality where ontological dependencies are detailed (an affordance may be defined as an ability realized by an agent (being physical or social). SAM consists of a 4 stage process (understanding problem domain; generating candidate affordances; candidate grouping; semantic modeling). This process must be completed recursively with frequent reference to stakeholders for checking the validity of the model. SAM is a method to elicit, analyze and represent the nature of reality by the affordances an agent perceives to exist: the basic patterns of agent`s behaviours are thus made explicit.

Norm Analysis Method (NAM) enables the patterns of behaviour of agents in the business system to be specified and articulated through norm identification (actions of agents being governed by social, cultural and organisational norms). Norms themselves may be specified in NORMA, a knowledge representation language, and be further translated into a computable language, LEGOL, for further processing (Liu, 2000). The resulting systems specification can be implemented in a dedicated software development environment, Normbase, or be implemented in any other programming languages. The norms are effectively used as function definitions or constraints on system functions and equate to the business dynamics within the domain.

A combination of SAM and NAM analyses can result in a semantic model which represents the processes of the organization (Salter & Liu, 2002). Modelling the semantics of an organization allows the requirements of the information systems to be more accurately reflected, and therefore to be embedded within IT systems. Thus, signs and norms (rules governing activities) are combined in an organizational semiotic analysis of the problem domain. As a philosophic basis for information systems development, OS replaces the classical distinction between entity, attribute and relationship with the concepts of agents, affordances and norms related to their antecedents to indicate ontological dependency (Stamper et al., 2000). For the remainder of the paper, we concentrate on NAM, and its advantages and challenges.

5 NORMS FOR REPRESENTING BUSINESS KNOWLEDGE

Employment of the norm-analysis method (NAM) will allow the behaviours of agents within a domain to be made explicit through norm identification and norm articulation. Norms may be defined as the rules or regulations which agents adhere to in the performance of their duties (e.g. stipulated hours of work). Norms may be categorized in a variety of ways (Stamper et al., 2000) and may be linked to the affordances within a domain (as defined through semantic modelling). Norms essentially capture the business dynamics and may be used as a basis for IT systems development. A norm may be represented in its` simplest sense as the formula:-

If <condition> then <consequent>

For example,

If <a person is a member of the site construction team> then <the person may enter the construction site>

Most business rules and regulations may be categorized as behavioural norms. These prescribe what people ‘may’, ‘must’ or ‘must not’ do, equating to the deontic operators: “permitted”, “obligatory” and “prohibited” (Liu, 2000). A behavioural norm may be represented as the formula:-

Whenever <context> if <condition> then <agent> is <deontic operator> to <action>

Using the Health & Safety Executive Work at Height Regulations (2005) relating to ladder usage as an example:

Whenever <a site worker is about to use a ladder> if <he will carry more than 10kg up the ladder> then <the site worker> is <obliged> to <complete a detailed manual handling assessment prior to performing the action>.

Similarly from a project management perspective we could say,

Whenever <a project manager is about to sign off a phase of site work as completed> if <the appropriate phase documents have not been marked as completed> then <the project manager> is <prohibited> to <initiate next phase of site work to commence>.

These norm definitions essentially capture the dynamics which occur. The following step is to put such formulae into programmable languages where applicable for IT application development. Norm analysis can only be complete and accurate following rigorous investigation of the problem domain with frequent reference to the agents themselves to assure accuracy of findings. The diversity and variety of norms existing within a domain should not be underestimated by the analyst nor should it be presumed that all norms identified can be technically realised. For example, cognitive norms address beliefs and knowledge of cultures (e.g. in Israel, Saturday is considered a day of rest, not Sunday); perceptual norms are concerned with how people receive signals from their environment via their senses (e.g. through light, sound, taste, etc.). Such norms are perhaps inappropriate for purely technical realisation. The challenge for mobilising OS oriented approaches for understanding the dynamics of specific contexts, and for providing OS based IT systems, is in incorporating the social and interpretive aspects of interaction.

6 ADVANTAGES AND CHALLENGES OF OS BASED APPROACHES

The ability to use norm-based rules to underpin and support information exchanges and decision making holds much promise for the development of new IS tools for construction work. Rather than rely on individuals to ensure that requirements for a particular decision or action are in place, and if necessary to go looking for that information, the system can mediate this process, both in terms of prompting the information suppliers and comparing requirements to what is present for the decision makers. But the example of the site worker given earlier shows another side to the interpretation of signs and information, where it is perhaps more difficult to represent this human centred processes of semiosis as norms or behaviours.

With this in mind, the following empirical examples are intended to illustrate both the sorts of issues an OS based information system might usefully support, as well as others which pose more of a challenge for information system provision. Both come from our on-going research on the construction of a new 20,000 m² office block in a city-centre location – the CC1 project (see Collinge *et al*. 2009). The examples are derived from interview material with project actors. The first example concerns the activities for providing utilities onto the project site, and the second concerns the role of a consultant operating on behalf of the client for the project.

6.1 *Getting Utilities on site*

Installing utilities onto construction sites for new buildings is a vital part of the project process, but can often be overlooked. It is also not straight forward, as not only must requirements for accommodating equipment such as transformers be incorporated into a building's design, but also the load structure of the network in the surrounding area must be accounted for. If it is already near full capacity, the surrounding infrastructure might also require additional (and often costly) 'reinforcement' work.

In order to get the utilities installed, there is a clearly defined process of providing the required information regarding the site, the building itself and its estimated load when occupied. With this information, a network design manager (NDM) checks the existing mains infrastructure records (an electronic database of maps overlaid with the mains network), assesses what is required, draws up plans for the installation and provides a quotation. If accepted, agreements are signed and the work is handed over to the installation team for the area. Currently, this process is performed by the NDM, who collates paper-based information to ensure that all the required information has been provided. This process can be expressed in NAM terms as:

Whenever <a quotation for work is accepted> if <all relevant information has not been submitted> then <the network design manager> is <prohibited> to <initiate the handover>

When the process is expressed in this form, it has the potential to be mediated through a norm-based information system which 'follows' these rules. It could be programmed to check all of the relevant information has been submitted, and either allow the handover process to proceed or flag up the need for further information.

However, other activities of the NDM are more challenging to define in this way. In assessing requirements for electrical loading, it is important to 'orientate' the actual site to the surrounding infrastructure. Design drawings can show the shape of the site, and the mains infrastructure records can

show where cables, etc. are located, but only through physically visiting the site can factors such as the proximity of overhead cables and pylons, or of other utilities and services, and even the contours of the site, be assessed. Therefore it is usual to visit the site before drawing up the plans for installation. This is a process utilising the NDM's range of experiential knowledge of previous work; in 'knowing' what to look for that cannot be represented by drawings or records, of past problems and solutions, to judge how to design the most effective installation plans for that specific site. It can also help to coordinate the installation of cables with other utility providers (such as data communications or gas).

This is a somewhat different process to checking the presence (or absence) of required information. It involves a different level of semiosis, grounded in the NDM's ability to interpret and make sense of a range of information, crucially including the physical layout of the site and surrounding area. This raises a question about whether and how this might be captured and expressed in the 'if... then...' format. The next example reiterates this challenge.

6.2 *Consulting for the client*

It is not unusual to have a particular consultant acting as main mediator between the project itself, and the client. On the CC1 project, one individual fulfilled this function, which included assessing design information and options for the client, liaising with the project's management about progress, design changes, legal issues and approving the release of funds from the client to the project's partners. This last process is interesting from an OS perspective. In order to release funds for a given period, this consultant has to reconcile progress on the project, including materials procured and used, with the quantity surveyor's reports to evaluate whether the work being charged for had been completed. For instance if certain materials are being invoiced, then the consultant would ascertain whether those materials had in fact been used, or delivered to the site ready to be used. Just concentrating on materials invoicing, we can formulate this process in the NAM format as:

Whenever <payment is requested> if <the materials detailed have not been used or delivered to the site> then <the consultant> is <obliged > to <withhold payment>

This seems straight forward enough and again has some potential to be embedded within an OS based information system. However, when we dig deeper into the detail of this particular activity, again we see something more subtle and more difficult to represent in this way. In order to assess what materials have been used or delivered, the consultant regularly goes to the project site. By looking around the site, a judgement is arrived at in terms of material used, but this is not just an exercise in counting. The consultant has to again utilise experience and personal judgement to assess not only what is present, but also what a reasonable level of tolerance might be for any observed discrepancy. Given the complexity and size of the CC1 project site, this is no simple affair, and requires 'overlaying' an understanding of the construction process (i.e. not all of the materials used might actually be visible) with what is observed on the site. Also, previous performance of the invoicing organisations might also influence the release of requested funds. Things become even more challenging when discrepancies do arise. In this case, the consultant liaises with the quantity surveyor, and between them they agree what the discrepancy is, and whether it is enough to withhold payment or request an amended invoice. The existing relationship between the QS and the consultant (in this case described as very good) also has a bearing on the decisions made. Overall, this is very much a process of negotiation and establishing what leeway might be given.

Both of these examples show how certain activities on the project are highly amenable to representation in the NAM format, and therefore potentially could be incorporated into or supported by, an OS / norm-based information system. The use of such norms for producing tailored interface design has been demonstrated by Bonacin & Baranaukas (2004) where specific 'norm' and 'action' management tools are used to derive a norm driven environment for system interface configuration, and Luo & Liu (2009) describe the potential for OS to inform information systems architecture design.

However, in examining these processes more closely we also find that some aspects seem much more difficult to format or represent in such a way. It is also these processes that involve a high level of human-centred semiosis – of using personal knowledge, experience and judgement to interpret information, whether this information comes in the form of documents, or as observations of the real phenomena.

7 CONCLUSIONS AND FURTHER WORK

This paper has outlined some of the challenges of providing information systems to support inter-organizational information exchange on construction projects. The introduction of OS provides a framework to consider not only technical information production and flow, but also the human-centred processes of semiosis that underpin interaction. Indeed, the provision of IT systems which are embedded with norms describing specific activities, such as ensuring required information has been passed between relevant actors, might go a long way towards better supporting these activities on construction projects.

However, we have also highlighted processes which, although central to discussions around OS theory, current methodological techniques struggle to capture and convert into something which can be incorporated into IT systems. The role of individual experience, knowledge and judgment are crucial to interaction, in broad terms as well as for the processes which happen on construction projects.

These two issues therefore provide the trajectories for our future research in this area. On the one hand, and for some interactions, making the transition from norm analysis methods to the provision of IT systems to support these activities is a realistic proposition. On the other, the continual exploration of ways to mobilize OS theory to capture and frame processes of human centered semiosis is a priority, as it is only through developing these techniques that more inclusive OS based information systems might be developed.

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