UNDERSTANDING CONSTRUCTION SUPPLY CHAINS: AN ALTERNATIVE INTERPRETATION

Ruben Vrijhoef[1], Lauri Koskela[2] and Greg Howell[3]

ABSTRACT

Much research work has assessed that construction is ineffective and many problems can be observed. Analysis of these problems has shown that a major part of them are supply chain problems, originating at the interfaces of different parties or functions. There have been several kinds of initiatives aiming at improvement and renewal of construction supply chains, but only few have a track record of consequent and significant successes.

Here construction supply chains are approached from an alternative theoretical viewpoint, namely that of the language/action perspective. In this approach, organizations are seen as networks of commitments. Two avenues have been pinpointed for practical application of this approach. First, the process of requesting, creating and monitoring commitments can be facilitated by heuristic models and computer systems, when suitably designed. Secondly, people can learn to communicate for action by developing new sensibility towards the ways their language acts participate in networks of human commitments, and improving their skills in understanding requests, and making commitments. By closer study, existing empirical observations support the idea that a large share of construction supply chain problems are caused by poor articulation and activation of commitments.

But would this new approach also facilitate the implementation of a new supply chain management that has proved to be so difficult in practice? In this regard, two initiatives are reviewed. The Dutch initiative to create a framework for communication in large civil engineering projects is first presented and initial experiences from its implementation are discussed. Then, Last Planner implementations are analyzed. By drawing on the concept of small wins, it is concluded that these implementations act as a stimulus for wider changes towards an environment of firm commitments and high trust.

The paper ends with a review on research tasks ahead.

KEY WORDS

Construction supply chain, language/action perspective, small wins

---

[1] Research Scientist, TNO Building and Construction Research, Department of Strategic Studies, Quality Assurance and Building Regulations, P.O.Box 49, NL-2600 AA Delft, The Netherlands, Phone +31 15 2695228, Fax +31 15 2695335, E-mail r.vrijhoef@bouw.tno.nl

[2] Senior Researcher, VTT Building Technology, Concurrent Engineering, P.O.Box 1801, FIN-02044 VTT, Finland, Phone +358 9 4564556, Fax +358 9 4566251, E-mail lauri.koskela@vtt.fi

[3] Director, Lean Construction Institute, P.O.Box 1003, Ketchum, Id, 83340, U.S.A., Phone +1 208 7269989, Fax +1 707 2481369, E-mail ghowell@leanconstruction.org

INTRODUCTION

Much research work has assessed that construction is ineffective and many problems can be observed. Analysis of these problems has shown that a major part of them are supply chain[4] problems, originating at the interfaces of different parties or functions (Figure 1). The current practice of supply chain management rightly suggests controlling the supply chain as an integrated value-generating flow, rather than only as a series of individual activities. There have been several kinds of initiatives aiming at improvement and renewal of construction supply chains in this spirit, but only few have a track record of consequent and significant successes.

In this explorative paper, we present an alternative interpretation of the problems and remedies to construction supply chains. The goal is to discuss the feasibility and usability of this new paradigm in the context of construction, and to reach a grounded view on the next steps for further unfolding of this emerging thrust.

The paper is structured as follows. First, we recapitulate the main results of studies on construction supply chains and related development initiatives. Next, we briefly outline the basic ideas of the language/action perspective. In the following section, we interpret construction supply chain problems from that perspective. Then, we present two initiatives, one related to information systems, another related to managerial action, that endeavor to implement ideas from the L/A perspective. Finally, we discuss the findings made and their implications for research and practice.
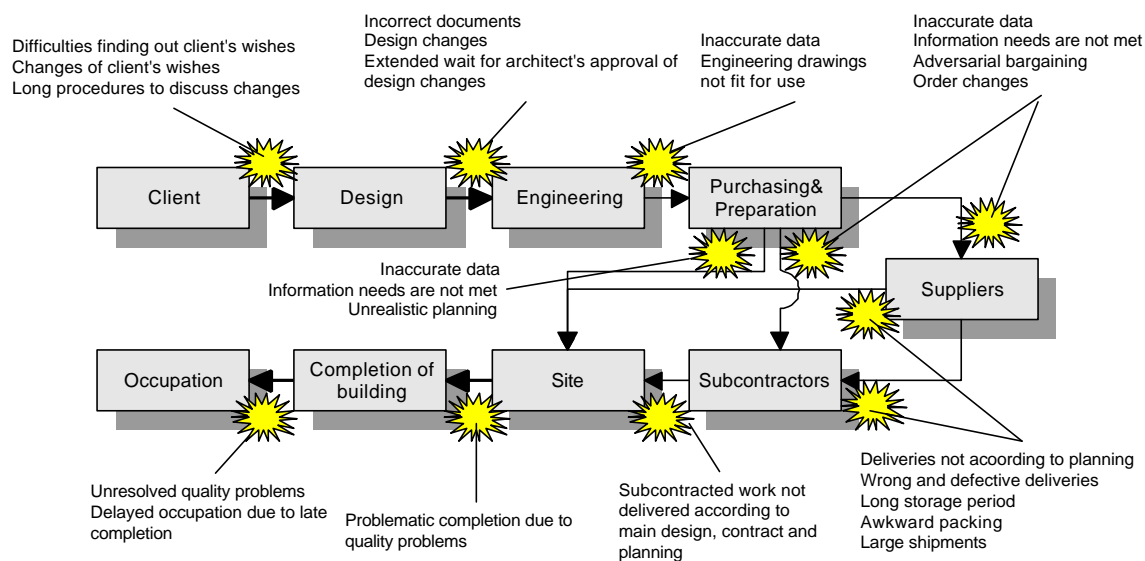
Figure 1   Generic problems in the construction process (based on Vrijhoef 1998)

---

[4] The term "supply chain" refers to the stages through which construction materials factually proceed before having become a permanent part of the building or other facility. It covers thus both permanent supply chains, that exists independent of any particular project, and temporary supply chains, configured for a particular project.

CONSTRUCTION SUPPLY CHAINS: PROBLEMS AND REMEDIES

In prior research, the authors have drawn three main conclusions regarding the present status of construction supply chains (Vrijhoef & Koskela 2000). Firstly, even in normal situations the construction supply chain has a large quantity of waste and problems. Secondly, most of these are caused in another stage of the construction supply chain than where detected. Thirdly, waste and problems are largely caused by obsolete, myopic control of the construction supply chain, characterized by independent control of each stage of the chain.

The status of construction supply chains does not seem to have changed much in the last decades. Higgin and Jessop (1965) observed that: '…any lack of cohesion and co-ordination is less the result of ill-will or malignancy on the part of any groups or [individuals][5], but more the result of forces beyond the control of any individual or group and which are affecting all'.

Unfortunately, these seemingly uncontrollable forces or their mental and organizational implications have thwarted almost every effort to improve supply chains. A part of the initiatives, such as open building system, sequential procedure, the new construction mode, design/build and partnering, have directly attacked this lack of cohesion and co-ordination. In addition, there are several generic initiatives, like re-engineering, time compression, quality and information technology, which have been recently implemented in construction. However, only few have a track record of consequent and significant successes, even if success in small scale has been reported[6].

What may be the reason for this lack of success? One hint is provided by Ekstedt and Wirdenius (1994) who compared a time compression program in construction with a corresponding program in manufacturing. They concluded that for builders with their project culture it is easier to implement renewal efforts. However, at the same time this means that a fundamental mental change was hardly needed in implementing the construction time compression program, and thus its cultural and mental influence was limited. But beyond this possible reason, could it be that the renewal efforts up till now have simply been theoretically misdirected and thus practically infeasible?

THE LANGUAGE/ACTION PERSPECTIVE

THE SEMINAL IDEAS

The interest into the language/action paradigm was initiated by the seminal book of Winograd and Flores (1986). They define the basic points of the theory as follows. Firstly, organizations exist as networks of directives and commissives. Directives include orders, requests, consultations and offers. Commissives include promises, acceptances and rejections. Secondly, breakdowns of conversation will occur, and the organization needs to be prepared. Thirdly, people in organizations issue utterances, by speaking or writing, to develop the conversations required in the organizational network. At the core of this communicative process is the performance of linguistic acts that bring forth different kinds of commitments.

Regarding the practical significance of this perspective, two avenues were pinpointed by Winograd and Flores. First, the process of requesting, creating and monitoring

---

[5] There is a misprint in the original; instead of "individuals", the word "groups" is repeated here. However, from the end of the sentence, it can be concluded that the intention was to say "any groups or individuals".

[6] A number of such renewal efforts have been evaluated in (Koskela 2000). A rare example of more successful methods is provided by vendor managed inventories, a method that has been relatively widely used in manufacturing, and is now being introduced also in construction.

commitments can be facilitated by computer systems. They present the idea of "the Coordinator", a computer system designed for constructing and coordinating conversation networks. Such a system directly supports the few conversational building blocks, such as request and promise, which implicitly occur in conversations for action[7].

Secondly, people can learn to communicate for action by developing new sensibility towards the ways their language acts participate in networks of human commitments, and improving their skills in understanding requests, promising commitments, etc. This line of exploration is further continued in the book of Solomon and Flores (2001), which focuses on the concept of trust, closely related to the concept of commitment. They claim that trust is not something that just exists or does not exist based on societal and institutional constraints, cultural atmosphere or individual psychology. Rather it must be seen as a matter of conscientious choice. Trust can be built by talking about trust and by trusting. Solomon and Flores suggest that trust must be built one step at a time, by way of interpersonal confrontations and mutual engagements, by way of commitments and promises, offers and requests.

FURTHER DEVELOPMENTS

Based on the work of Winograd and Flores (1986), Dietz (1996, 2001) developed a theory that enters into the commitment issue in an organizational perspective in terms of communicative action. Organizations have previously been described as 'the coordination of efforts of people working on a collaborative task broken down in a set of specialized activities. Coordination is then achieved through communication' (Taylor 1993). This kind of communicative coordination has previously been defined as: 'communication mediated co-ordination of human action' (Habermas 1984), or 'communication by feedback' (March & Simon 1958). Communication in organizations can then be viewed in two perspectives: the informational perspective, implying just the exchange of facts, opinions and descriptors (informative communication), and the organizational perspective, including notions of obligations, responsiveness, communication imposed actions etc. (performative communication).

In this sense, communication is not merely the exchange of information, but the constellation of a message with representational, functional and action characteristics, which is part of a communication process aiming to coordinate objective action. In fact, objective action is basically embedded in communication: preceded by as well as succeeded by performative conversations. Both conversations are respectively aimed at the agreement about a future objective action by one of the actors involved, and at the agreement about the result of the objective action.

In their DEMO methodology, Van Reijswoud and Dietz (1996) developed an organizational (inter)action model including the definition of actors' roles, and intermediate transactions (sequences of the preceding conversation, the execution of the action and the succeeding conversation). In the methodology a business system is represented as a coherent structure of roles, actors and intermediate transactions. The progression of transactions is basically the representation of the business process.

Besides, business systems, such as organizations, must basically be viewed as social systems, not rational systems. Within a social system, such as an organization, the actors are

---

[7] Flores and others have patented and commercialized such a system (U.S. Patent 6,073,109. Inventors: Flores, et al. June 6, 2000). It is worth noting that detailed communication languages to express transactions are also being developed in the framework of Electronic Data Interchange (EDI) and Web-based project management systems. However, to our knowledge, such work is not generally based on the L/A perspective, and thus lacks the key features, such as learning from breakdowns.

individuals who continually enter into commitments towards each other, and choose to fulfill the commitments, within the context of shared norms and values, and notions of authority and responsibility. Thus, basically, business processes are sequences of commitments between authorized and responsible social actors or individuals.

CONSTRUCTION SUPPLY CHAINS: INTERPRETATION FROM THE LANGUAGE/ACTION VIEWPOINT

Does the language/action perspective provide a useful conceptual basis for analyzing construction supply chains? In other terms: to what extent can the language/action paradigm explain and predict what is happening in construction supply chains?

Rather than aiming at systematic validation, we present initial evidence for the relevance of the language/action perspective by considering such problems in construction supply chains which can be associated with that perspective.

CONSTRUCTION SUPPLY CHAIN AS A NETWORK OF COMMITMENTS

Analogously to a business organization, one way a construction supply chain can be understood is as a network of commitments, emerging from successive conversations for action. Let us investigate how these conversations and commitments are regularly carried out in the critical phases of a construction supply chain: design, materials procurement and logistics, and site coordination.

In a thorough study on design management (Arnell & al. 1996), the central problems found were defined as follows: 'The involved persons perceive uncertainty on what has to be done, who has to do it and when it has to be ready. The actors in the design project organization have no common and clear understanding on what should be designed'. In other words, this indicates that conversations for action were either ineffective or missing altogether in the coordination of design.

Wegelius-Lehtonen et al. (1996) found various logistics problems, in various stages of the construction supply chain. Many of the problems referred directly and indirectly to insufficient coordination, communication, and thus commitment, such as failures to inform about schedule changes, late confirmation of deliveries, and lack of feedback procedures.

Regarding site coordination, Bennett and Ferry (1990) found that '...the specialists [contractors] are just thrown together and told to sort things out between themselves'. This kind of phenomena that are regularly occurring in the supply chain are basically the root of misunderstanding, initiated by a complete lack of coordination and structure in the communication and collaboration, and thus commitments, on site.

In fact, the study of Josephson and Hammarlund (1996) about quality defect costs summarizes well the situation in construction: they claim that the majority of causes for defects are related to various forms of ambiguity, such as ambiguity about client's wishes (e.g. concerns, interests and requests), ambiguity about organizational structure and responsibilities (e.g. actors/performers, agreements and promises), and ambiguity in drawings (e.g. descriptors of conditions and client specifications).

DISCUSSION

Existing empirical observations support the idea that a large share of construction supply chain problems are caused by poor communication, and lacking articulation and activation of commitments. It would be tempting to explain these problems by the neglect of methods based on the L/A perspective. However, there might be other reasons for these problems,

such as a poor theory of management[8]. On the other hand, we must not want to explain only: we also need evidence for the effectiveness of the implementation of methods based on an articulated L/A perspective in construction supply chains.

Few initiatives have tried to take up the issue of the L/A perspective. The Dutch initiative VISI, which has created a framework for communication in large civil engineering projects, provides an example of primarily information system oriented approach towards the utilization of the L/A perspective. The Last Planner method has been developed independently, but it shares many traits with the L/A perspective. The Last Planner method is interpreted here as an approach towards utilizing ideas of the L/A perspective by providing a structure for communication for action and by training people to use it. These two initiatives are analyzed in the following sections.

FORMALIZING COMMUNICATION AND COMMITMENT IN CONSTRUCTION SUPPLY CHAINS: THE DUTCH INITIATIVE VISI

In the construction supply chain language/action issues are typically related to information and communication problems, and in essence to commitment problems. From an organizational perspective the DEMO methodology by Van Reijswoud and Dietz (1996) was used for creating the VISI framework to formalize communication, and to structure commitment within civil engineering projects (Schaap et al. 2001). However, the framework is generic by nature, and may thus be applied to various kinds of construction sectors. Its ultimate objective was to develop a generic model for digital communication.

Based on the DEMO format, the VISI framework represents a project organization model for the unambiguous (pre)definition of roles, transactions, transaction diagrams, messages, and data elements within a construction project (Schaap et al. 2001).

The VISI model is basically structured around the system requirements for effective communication by agreements. The agreements are defined in terms of transactions. Analogously to the DEMO methodology, a transaction exists if two parties enter into a performative conversation, and agree to perform a specific action with a particular result. Communication agreements include three phases: commission, execution, and acceptance (Figure 2).
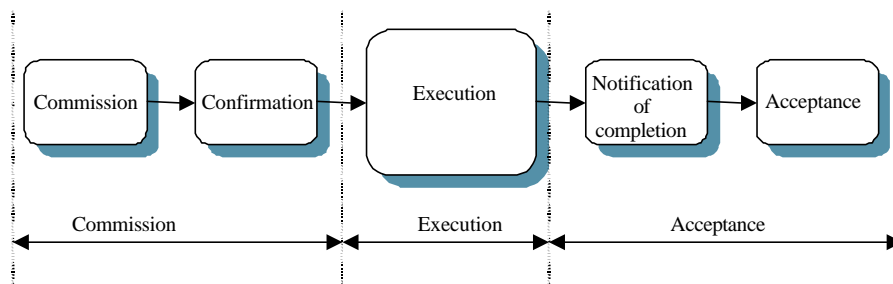

Figure 2   Three phases of a communication agreement (Schaap et al. 2001)

In the VISI model the roles of actors, and the corresponding tasks and responsibilities are predefined in a transaction. The roles involved in a transaction are the initiator and the executor (Figure 3). Transactions are accompanied by various issues in order to facilitate

---

[8] Here we encounter the question to which extent it is possible to separate purely managerial aspects and communication aspects from management in general. Clearly, this question should be addressed in future research.

and assure follow-up and action, such as the required initial information per transaction, technical and organizational prerequisites, delivery procedures and definition of results.
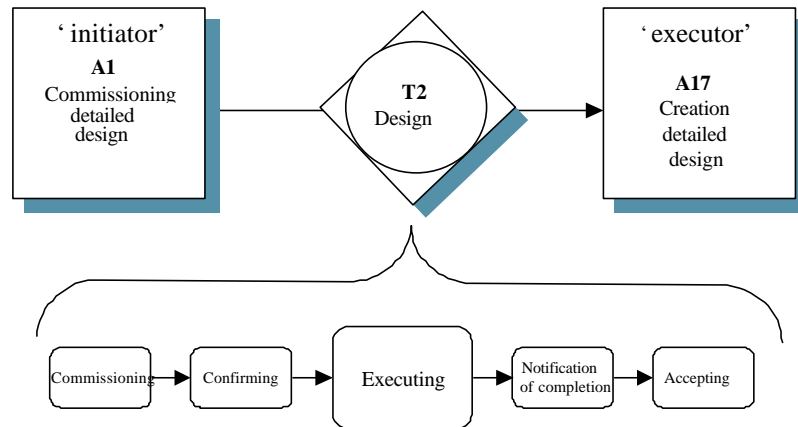

Figure 3   Two roles in a transaction (Schaap et al. 2001)

The VISI framework consists of a generic model defining all actors' roles and intermediate transactions (Figure 4). For the actual application in construction projects, the generic model must be detailed into a specific (inter)action model, including a specific description of transactions, roles and messages, with specific information and communication characteristics. However, when specifying, the generic model is leading, rather than the formal features of the project, such as contract arrangements.
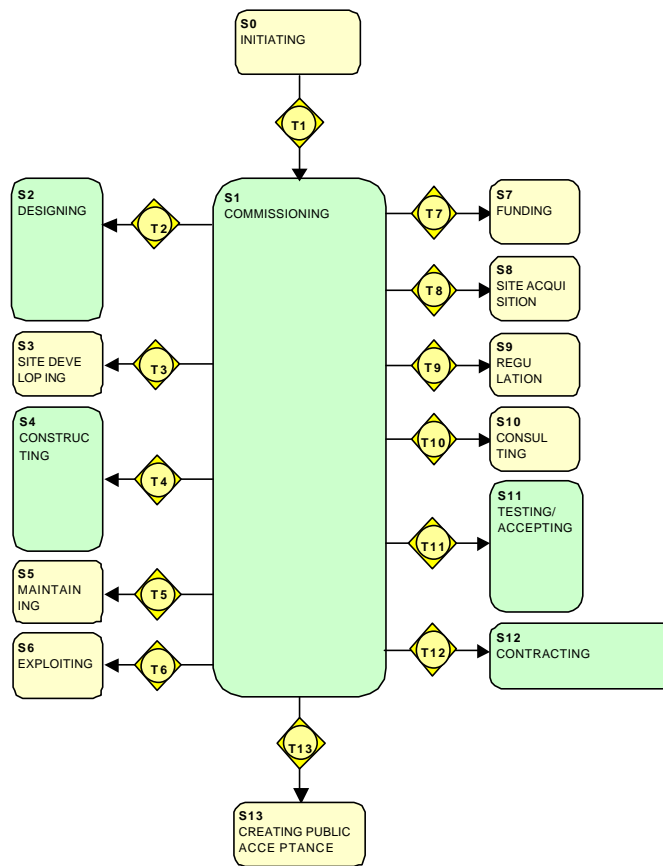
Figure 4   Generic (inter)action model of roles and transactions (Schaap et al. 2001)

The roles of the actors may be determined on basis of various considerations, such as knowledge and experience of the actors. From the perspective of optimal communication, the number of organizational boundaries, and thus the number of actors, should be minimized, such as in an alliance or partnering model. Obviously, then there will be fewer limitations in the information transfer, and thus more efficient communication.
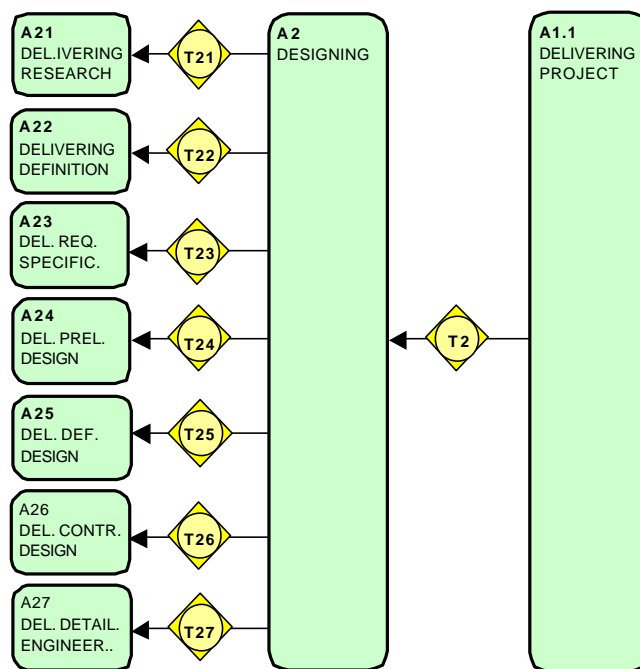
Figure 5   Breakdown of the roles and transactions of design (Schaap et al. 2001)

At this point in time, over fifty roles and transactions have been defined in the VISI model. Each transaction is described by a transaction diagram (including standardized messages), predefining the purpose of the transaction, the parts of the transaction and the direction of the messages, represented by an arrow in the diagram (Figure 6). In the below sample diagram, the transaction diagram is presented for the delivery of the total design between the party who designs the project and the party that (ultimately) delivers the project (Figure 5: transaction T2). The transaction is subdivided in formalized messages in a prescribed sequence (CA1 to CA4.4). Each message is located in a particular transaction phase ("Commission given" to "Result accepted"), indicating which of the two parties ("A1.1 Project delivering" or "A2 Designing") is delivering to whom (indicated by the arrows).

The messages structure and formalize the communication between the actors involved in the transaction. Each transaction is aimed at securing the promises to perform a particular task by the actors until the declaration of completion of the task. Ultimately, all transactions are aimed at (re)committing to the objective of the project.

OBJECTIVE: DELIVERY OF ALL DOCUMENTS AND SERVICES WHICH ARE PART OF TOTAL DESIGN

RESULT: TOTAL DESIGN DELIVERD (DOCUMENTS OF (PARTIAL) RESULTS A.O. DRAFTS, CALCULATIONS, DESIGN MEMO, COST ESTIMATE, PLANNING).

Transaction phase:

Message type:

Message type		Commission given	Commission accepted	Execution	(Partial) Result offered	(Partial) Result accepted
CA1	Commission	ß				
CA2:	Confirmation of commission		Ý			
CA3.1.1	Notification of completion				Ý	
CA3.1.2	Report of deviation and additional/less work			ß		
CA3.1.3	Reply to report of deviation and add/less work			Ý		
CA4.1	Acceptance results and deviations					ß
CA3.2.1	Report of progress			Ý		
CA4.2	Acceptance progress report			ß		
CA3.3.1	Notification of completion term of work				Ý	
CA4.3	Performance statement term of work					ß
CA3.3.2	Offering declaration (term of work)					Ý
CA3.4.1	Offering (partial) result for quality assessment			Ý		
CA4.4	Reporting results of quality assessment			ß		

A1.1
Project delivering
leverende

A2
Designing

Figure 6   Sample of a transaction diagram (Schaap et al. 2001)

The VISI model has been tested in a number of real-life construction projects regarding such aspects, such as the communication between the principal and the contractor, and the general management of the project. Until now the model has been tested as a conceptual model. An information system will be developed and tested in the near future. First experiences in the real-life projects showed that the projects progressed more successfully than normal, because the communication was more effective and responsibilities were clearer. Apparently, the model had a positive effect on the structure of the commitment and communication within the construction supply chain.

CREATING COMMITMENT IN THE CONSTRUCTION SUPPLY CHAIN: LAST PLANNER

THE LAST PLANNER METHOD FROM THE VIEWPOINT OF THE LANGUAGE/ACTION PERSPECTIVE

We contend that the Last Planner method (Ballard & Howell 1998) realizes some of the key ideas of the language/action perspective. Instead of providing a comprehensive account of this method, which can be found from (Ballard 2000), we focus on similarities between it and the L/A perspective.

Firstly, this method provides for a *structure* for conversations for action, regarding coordination of weekly tasks. Secondly, it creates *clarity* regarding assignments of different parties. Thirdly, it elicits *commitment* towards the task assigned. Fourthly, it requires explicit *declarations of the completion* of the task. Fifthly, it brings attention to the *breakdowns* (i.e. non-completion), in the sense of Winograd and Flores (1986), for recommitting to the promises of the project and for learning about the system.

There are differences, too. The conversation structure of the Last Planner is not specified at such a detailed level as suggested by the L/A perspective. The Last Planner method is tailored to a specific situation, namely weekly coordination of operations, whereas the L/A perspective is generic.

However, the question which is most interesting here is whether a change towards a high-commitment, high-trust business organization or supply chain can be achieved by means of the Last Planner.

ACHIEVING THE CHANGE

There are two generic approaches to organizational change (Beer & Noria 2000). One approach focuses on formal structures and systems, and it is implemented in a top-down manner. The main purpose is the creation of *economic value*; hence it can be called the theory E. The other approach focuses on the development of a culture of high involvement and learning. Its purpose is the development of the *organizational capability*; hence the theory O. It is implemented in a participative manner.

In construction, the theory E has mostly been used for organizational change, but often with some input by the theory O (of course, the temporary nature of the project organization has been an obstacle for a wider use of the theory O). However, as argued above, the efforts of organizational change cannot be characterized as generally successful in construction. Instead, for explaining the phenomena observed in the implementation of the Last Planner, we draw on another model of organizational change that transcends the dichotomy of the E and O theories.

Weick (1984), a noted social scientist, has defined an approach to solve major social problems, called *small wins*[9]. Major social problems are often defined in ways that overwhelm people's ability to do anything about them. Instead, if a larger problem is redefined as a set of smaller problems, people can identify a series of controllable opportunities of modest size that produce visible results that can be assembled into wider solutions. When a solution is put into place, the next solvable problem may become more visible. A pattern is built that attracts allies and deters opponents. Also, small wins may be seen as miniature experiments that test implicit theories about resistance and opportunity. They can uncover resources and barriers that were invisible at the outset. A series of small wins is also more structurally sound than a large win because small wins are stable building blocks. Instead, a large win requires much more co-ordination and may fail due to a missing critical piece.

Thus, in summary, there are a number of characteristic features in this approach (Meyerson & Fletcher 2000) such as: it names the problem; it combines changes in behavior with changes in understanding; small wins have a way of snowballing: one small win begets another, and eventually these small changes may add up to a new system.

LAST PLANNER SEEN THROUGH THE LENS OF SMALL WINS

The problems of construction have existed long since, and apparently it has not been possible to do much about them. Even if not among the major societal problems, the "malaise of construction" represents for all related actors an overwhelming issue, i.e. forces beyond control. Thus, it is tempting to ask whether small wins could be applied to construction?

---

[9] Weick credits Tom Peters as the author of the original description of small wins. Recent application of this approach in the efforts to shatter the Glass Ceiling (Meyerson & Fletcher 2000) has revived attention to it.

In the following, we endeavour to show that in practice the Last Planner may induce a series of events that corresponds to the description of small wins. Thus, the approach of small wins gives a theoretical explanation from one angle to the success of the Last Planner. This is illustrated in the following.

Naming the problem

Instead of being content with the "forces beyond control", that is a problem with no name, the Last Planner defines a small, but critical and actionable sub-problem: the ability of the last planner (in the hierarchical chain of planners, starting from those preparing the most general and comprehensive plans) to plan assignments for crews.

Changes in behaviour and changes in understanding

Accounts of implementation cases vividly show how, first enforced changes in behaviour led to changes in understanding and then voluntary changes in behaviour:

'It took a great deal of effort initially to get the subcontractors to work together (for example, co-ordination of plumbing and duct work). […] The foremen admitted that they initially thought the meetings held at the beginning of the project to build the master pull schedule were a waste of time, but once they saw the system work, they all agreed that it was a valuable experience. […] The foremen stated that this project had an entirely different atmosphere than others they had worked on - the subcontractors communicated among themselves and co-ordinated their work. On a typical project, they were not concerned with other subcontractors. […] The foremen interviewed stated that this project experienced less rework due to better co-ordination between subcontractors. It took active participation by all parties to make the process work smoothly, though - poor planning by one subcontractor could affect all the others. This most often happened with inaccurate information about when prerequisite work would be completed. The accuracy and reliability of schedules and plans were very important. Increased communication resulted in more of a team concept than the typical situation where each subcontractor looked out for its own interests - both at the foreman and craft levels.' (Pappas 1999)

One small win begets another; snowballing

Furthermore, accounts of implementation show that one small win begets another, and that the change propagates through snowballing:

'Companies beginning to implement lean report an unexpected phenomenon; each change creates the opportunity for more and often larger improvement. Thus, for a time it appears that the amount of change possible increases with each step of implementation.' (Howell & Ballard 1998)

'Two foremen said that their companies considered adopting Lean Construction as a standard operating procedure. One said his company had already started using it on other projects. They felt that the principles would help their companies, even if they were the only ones on the project using them. They knew how to better load manpower, schedule their work, and schedule material deliveries so they did not have to relocate material. […] The owner's project management staff was planning to adopt it [Lean Construction principles] for all future projects, because it worked so well on this project.' (Pappas 1999)

Discussion

It could be argued that as long as the "forces beyond control", that lead to lack of cohesion and co-ordination in supply chains, can rage without restraints, then any effort to ameliorate construction management in general, and supply chain management in particular, is doomed to failure. However, examples show that a strategy of small wins that form a pattern towards a new system design may effectively be used for renewing at all levels needed: mental, procedural and system level. Initial evidence indicates that the method of the Last Planner provides a structure for triggering such small wins. Thus, a task for future research is to provide deeper understanding on the features of Last Planner method that function as the core mechanisms for the formation of trust. From a more practical point of view, it has to be investigated how the Last Planner method could systematically be used for achieving high-commitment, high-trust atmosphere along the whole supply chain in construction.

CONCLUSIONS

Analysis has suggested that the language/action perspective provides a plausible explanation for many root causes of the problems in construction supply chains. A review of related methods and tools, being presently developed or implemented, gives reason to a guardedly optimistic view on the practical usability of this approach in construction. The methods related to information and communication systems are still primarily in the development phase, and their evaluation can be carried out in the future. However, the case of the Last Planner illustrating managerial methods indicates that such a method – besides bringing about direct efficiency gains - may stimulate wider organizational change towards a higher level of commitment and trust.

Thus, it seems that the language/action perspective is defining a worthwhile new research topic, also for construction management, as it has done in other disciplines. Several challenging tasks are waiting. At the level of theory, the conceptual model of the language/action perspective has to be compared to earlier conceptual schemes representing the same phenomenon, but from a different angle, such as the transaction cost model or the supplier-customer scheme of the quality paradigm. At the level of empirical research, practical experimentation with the new ideas and methods may provide a fruitful approach.

REFERENCES

Arnell, V., Hammarlund, Y., Liedholm, M., and Sverlinger, P.O. (1996) *Kvalitetsförbättringar i bygg- och anläggningsprojekt* (In Swedish: Quality improvements in building construction and civil engineering projects). Chalmers Tekniska Högskola, Institutionen för byggnadsekonomi och byggnadsorganisation. Report 47. Göteborg. 12 p.

Ballard, G. (2000) *The Last Planner System of Production Control*. Thesis submitted to the Faculty of Engineering of The University of Birmingham for the degree of Doctor of Philosophy. School of Civil Engineering, Faculty of Engineering, University of Birmingham.

Ballard, Glenn & Howell, Gregory (1998) Shielding Production: Essential Step in Production Control. *Journal of Construction Engineering and Management*, Vol. 124, No. 1, pp. 11 - 17.

Beer, M., and Noria, N. (ed.). (2000) *Breaking the Code of Change*. Harvard Business School Press, Boston. 507 p.

Bennett, J., and Ferry, D. (1990) "Specialist contractors: A review of issues raised by their new role in building." *Construction Management and Economics*, 8, 259-283.

Dietz, J.L.G. (1996) *Introductie tot DEMO: Van informatietechnologie tot organisatietechnologie* (In Dutch: Introduction to DEMO: From information technology to organization technology). Samsom, Alphen aan de Rijn. 70 p.

Dietz, J.L.G. (2001) "DEMO: Towards a discipline of organisation engineering." *European Journal of Operational Research*, Vol. 128, 351-363.

Ekstedt, E., and Wirdenius, H. (1994) "Enterprise Renewal Efforts and Receiver Competence: The ABB T50 and the Skanska 3T Cases Compared." Paper presented at the IRNOP Conference, Lycksele, Sweden, March 22-25, 1994. 18 p.

Habermas, J. (1984) *The theory of communicative action: Reason and rationalization of society*. Polity press, Cambridge.

Higgin, G., and Jessop, N. (1965) *Communications in the Building Industry*. Tavistock Publications, London. 125 p.

Howell, G., and Ballard, G. (1998) *Implementing Lean Construction: Understanding and Action*. Paper presented at the IGLC-6 conference.

Josephson, P.E., and Hammarlund, Y. (1996) *Kvalitetsfelkostnader på 90-talet – en studie av sju byggprojekt* (In Swedish: Quality defect costs in the nineties - a study on seven building projects). Del I. Report 49. Chalmers Tekniska Högskola, Institutionen för byggnadsekonomi och byggnadsorganisation. Göteborg. 125 p.

Koskela, L. (2000*) An exploration towards a production theory and its application to construction*. VTT Publications 408, VTT, Espoo.

March, J.G., and Simon, H.A. (1958) *Organizations*. John Wiley, New York.

Meyerson, D.E., and Fletcher, J.K. (2000) "A Modest Manifesto for Shattering the Glass Ceiling". *Harvard Business Review*, January-February, 127-136.

Pappas, M. (1999) *Evaluating Innovative Construction Management Methods through the Assessment of Intermediate Impacts*. A thesis for a Master of Science in Engineering, University of Texas at Austin.

Reijswoud, van, V.E., and Dietz, J.L.G. (1999) *DEMO Modelling Handbook: Volume 1*. Delft University of Technology, Delft. 173 p. (Version 2.0 downloaded from http://www.demo.tudelft.nl/)

Schaap, H., Nieuwenhuizen, L., Jongedijk, H., Buijs, C., Hamilton, J., and Vroomen, de, A. (2001) "VISI: A Methodology to Standardize Communications in Civil Engineering." *4th International EUROSIM Congress*, June 26-29, 2001. Delft, The Netherlands.

Solomon, R.C., and Flores, F. (2001) *Building Trust in Business, Politics, Relationships, and Life*. Oxford University Press, New York.

Taylor, J.R. (1993) *Rethinking the theory of organizational communication*. Ablex, Norwood. 302 p.

Vrijhoef, R. (1998) *Co-makership in construction: towards construction supply chain management*. MSc Thesis. Delft University of Technology / VTT Building Technology, Espoo.

Vrijhoef, R., and Koskela, L. (2000) "The four roles of supply chain management in construction." *European Journal of Purchasing and Supply Management*, 3-4 (6), 169-178.

Wegelius-Lehtonen, T., Pahkala, S., Nyman, H., Vuolio, H., and Tanskanen, K. (1996) *Opas rakentamisen logistiikkaan* (In Finnish: Handbook for logistics in construction). Rakennus Teollisuuden Keskusliitto, Helsinki.

Weick, K.E. (1984) "Small Wins: Redefining the Scale of Social Problems". *American Psychologist*, 1 (39), 40-49.

Winograd, T., and Flores, F. (1986) *Understanding Computers and Cognition: A New Foundation for Design.* Ablex, Norwood. 207 p.