Complexity and Sensemaking in Construction

Finn Orstavik[1]

Abstract

Mainstream construction project management is based on a linear conceptualization of time. The fundamental task of management is taken to be the organizing of a project in such a way that the diverse parts of the project play together; each part facilitating the operation of the whole, and avoiding that some operations obstruct other operations.

At the same time, complexity is recognized in the construction literature as being a major obstacle to efficient and effective building. Complexity temporalizes construction, and entails shortage on relevant information and unpredictability for builders. This produces uncertainty and risk, as operations have to be based on guesses about the future state of affairs. Reduction of risk can be achieved by improving on the ability to formulate successful and effective predictions. The question posed here is whether this is best done with the traditional approach to project management, or if it is necessary to focus more on collaborative involvement of stakeholders, with emphasis on creativity and self-organization, rather than management command and control.

It is here proposed to see the question about what is the best approach to construction project management as a question regarding how to cope with complexity. With inspiration from novel social theory, it is argued that dealing with complexity is related fundamentally to processes of sensemaking.

The communication in a construction project and in one specific project meeting is analysed. The main finding is that although command and control related communication and retrospective sensemaking play a significant role, more complex communication encompassing future oriented sensemaking and sense-giving take up a lot of time and plays a major role in the way complexity is dealt with in the project.

Keywords: Communication, Complexity, Construction, Sensemaking, Time.

1. Introduction

In the dominating approach to construction practice today, the institution of universal, clock time, linear project schedules, and labour agreements regulating time use are all key

[1] Associate Professor; Department of History, Sociology and Innovation; University College Vestfold; PO box 2243 3103 Tonsberg, Norway; finn.orstavik@hive.no

elements. Construction project management is based on a linear conceptualization of time. The fundamental task of management is taken to be the organizing of a project in such a way that the diverse parts of the project play together; each part facilitating the operation of the whole, and avoiding that some operations obstruct other operations (Morris and Pinto, 2007). As in F. W. Taylor's well known time studies from the early 20th century, the objective is to minimize the obstructive potential of dependencies, and to rationalize work by simplifying operations and reducing movements, resulting in maximum output being produced with a minimum of cost.

This highly mechanical and linear formulation of the issue of organizational efficiency has been challenged from several sides. For example, social scientists at the Tavistock Institute in London in the early year of Taylor-inspired rationalization pointed out the limitations of the approach: People are not machines but social beings, and people have to be dealt with by management in completely different ways than machines (Emery and Trist, 1965). Other, more recent research has shown that the successful integration of diverse people across professions and knowledge domains is instrumental for effective problem solving and production efficiency. Multidisciplinary teams in situations of high complexity depend on tacit knowledge and on integrating innumerable clues in order to establish coherence, and to achieve effective problem solving. No outside coordination based on predefined categories and schedules can cope effectively with this, as the involvement, commitment and creative efforts of those involved are essential for outcomes (Oborn and Dawson 2010).

In the research literature on construction and on construction project management, the notion that construction projects are complex is widely accepted (Cicmil and Marshall, 2005; Gidado, 1996; Winch, 2010). There is also broad agreement that effective management is a basic precondition for project success. But on the key issues how complex projects should be coordinated, and what the actual role of management should be in making complexity manageable, there are diverging views. In fact, in the study of construction project management, it can be argued that two irreconcilable positions stand against each other: On the one hand, construction activities and project organizations are understood as depending fundamentally on centralized power and temporally linear managerial co-ordination for efficacy and efficiency. On the other hand, construction is conceived of as complex processes depending fundamentally on self-organization, creative problem solving, and on negotiation of multiple temporalities.

In social theory efforts are currently being made the concepts of *temporality* and *emergence* are being positioned pretty much in the bull's eye of this theoretical debate (Emirbayer and Mische, 1998). Theories of complex, dynamic systems (for example Luhmann, 1984); a concept of time as a lived and continually redefined amalgamation of past, present and future (Mead, 1932), and not least process oriented theory of sensemaking in complex organizations (Weick, 1979 and 1995; Weick and Sutcliffe, 2007) are increasingly being recognized as valuable in this effort.

The objective in this paper is to draw on insights from this developing theoretical field, in an exploration of the seemingly irreconcilable perspectives on how to cope with complexity in construction, and what the basic function of management is in this context. Looking at project

management and complexity through the lens of sensemaking; which of the opposed perspectives come closest to a true rendering of realities in construction projects, and in efforts to cope with complexity in construction?

2. Complexity and sensemaking in construction

Both social and technical systems are temporal phenomena. Elements and relationships are of many different kinds and can be transformed over time in diverse ways. This implies that systems can be very complicated phenomena to map and to understand. But what does it mean that systems are complex? Luhmann (1984) answers this question by considering the number of possible linkages between elements in systems. Complexity arises in systems *as elements are increasingly unable to establish direct relationships to all other elements*, as the number of elements in a system go up and the number of potential linkages goes up much more. Elements have a limited capacity to link with other elements. As systems grow, the number of possible direct links that are not actually established increases rapidly, and the lack of direct links establishes complexity in the system. Complexity is essentially the somehow patterned, but unpredictable dynamics that is produced by the actual relating that occurs between elements in a system.

Two general implications concerning the coping with complexity in a system are obvious: First, that integration (establishing relationships) is essential for all efforts to deal with complexity. Second, that since the multitasking ability of all elements is finite there can be no way to integrate a large system completely.

Distinguishing between complexity of a building as a material object and the complexity of a building process as such, it can be argued that both are complex and dynamic systems, even though one is much more obviously dynamic than the other. The fundamental source of complexity in the building and in the building process is not in itself the many elements and their manifold linkages, but rather the lack of linkages between elements, the temporal variability of dependencies, and the many indirect dependencies between seemingly unrelated elements. Linkages between elements are organized, but not always in obvious ways.

In the planning and coordination of building operations, tasks and contributors are conceptualized by designers and project managers as elements within a system of systems. For instance, in the progress plan, particular tasks make up diverse elements, with a number of dependencies indicated or implied between each of them. Firms, individuals, materials, machinery, plans (such as drawings) make up other subsets of elements, and also between these there are dependencies. This means that the project is made up to be a system, much in the same way as the building itself. The systemic nature of the project is co-created by stakeholders, and presumably this co-creation is nurtured by project management.

Integration cannot be complete in large systems, hence there will always be elements that are indirectly linked, and systems functions that are hard to decipher. In principle, then, there will always be effects of systems events that have to be experienced, since they cannot be predicted. The link between cause and effect is opaque. This is why visitors to building sites often see only chaos, where people with more experience see the situation as meaningful and as more ordered. Experienced construction workers, technical sub-contractors and

project managers are knowledgeable in the sense that they have the ability to make sense of events in complex situations, and they are generally savvy when it comes to making guesses, and to make productive decisions even when relevant information is scarce.

Sensemaking is an activity closely intertwined with complexity, and that it is a basic mechanism for people and organizations to cope with and manage complexity. Karl Weick, at the same time building on and contributing to the literature on designing and managing complex organizations, has conceived of sensemaking as a cognitive process that people engage in primarily when it – in a literal sense – becomes painfully obvious for them that their existing ideas about reality is inadequate.. According to Weick, sensemaking is a process that tends to be triggered by chaos; at instances when it is realized that the world is different from what it was expected to be. Weickian sensemaking is basically retrospective. People contemplate experiences, draw on available information and try to make sense of occurrences and cause-effect relationships that can help relate the present with the past (Weick, 1979, 1995).

Gephart et al. (2010) makes the point that sensemaking is not always made in a response to crisis. Active sensemaking can also be triggered by a need to understand what will happen in the future. Forward looking pro-active human beings may well engage in sensemaking as a preparation for their own future, and for the future of others. Gephart et al. furthermore refer to works by Maitlis and others, when they define the term sense-giving as influencing others to make sense of things in a way that reflects their own preferred redefinition of reality (Gephart et al., 2010, p 278; Maitlis, 2005; Maitlis and Lawrence, 2007).

3. Analysing sensemaking in construction

3.1 Analytical approach and methods

Are construction activities and project management basically depending on centralized power and command and control, top-down managerial, temporally linear co-ordination for efficacy and efficiency, or should the root causes of effectiveness and efficacy in construction be sought in ongoing processes of broad decisionmaking involvement, self-organization, distributed creative problem solving, and active negotiation of multiple temporalities? The research on this, reported in the following, is based on empirical analysis of original data that have been gathered in an ongoing, mission critical construction project over a four year period. The project was carried out by a major Norwegian contractor in Oslo, and encompassed five different buildings; four new structures and one refurbished 14 floors apartment building.

Construction projects go on in construction sites, but in reality activities that are important for the project are distributed both in time and in space that extends far outside the perimeters of the site itself. This fact and the complex nature of construction projects make the conduct of comprehensive analyses of communication and sensemaking in construction extremely challenging. In order to understand realities of construction, grasping what goes on in meetings gives only a limited view of the whole effort, but it is still relevant and important. Meetings are significant arenas for the diffusion of information and for active decisionmaking,

and are not least crucial for managerial involvement in the construction process. It is much easier to evaluate communication taking place in formal project meetings, than in the project as a whole. But it is impossible to understand fully what goes on in a meeting for observers that are not knowledgeable about the broader context, and about the specific project and the stakeholders involved in it.

The design of the analysis and the data gathering effort reported here was divided in two phases. In the first phase, a broad mapping of the project was undertaken. Stakeholders and roles were mapped on the level of individuals and organisations. Since the project and stakeholder involvement was constantly changing, this mapping of actors and activities was longitudinal in nature, and corresponding to the methods for longitudinal data collection in innovation projects laid out by Poole, Van de Ven et al. (2000).

Four years of research involvement in the construction effort meant that the project was observed during its pre-design and design phases, and then for two years in its actual production phase. In the design phases, observation in engineering and design meetings was combined with face-to-face interviews with participants carried out in their own offices off the building site (f. ex. in the architect firm). Later, in the production phase on-site, data was gathered both in ongoing engineering- and design meetings, in progress meetings and in other coordination meetings (cfr. table 1), and more interviews were carried out with participants on site and off site. In addition, regular visits were made to the construction site, in order to monitor progress of operations and to have informal conversations with workers in the operational context. All formal meetings attended were digitally recorded and about a dozen were fully transcribed.

Table 1: Categories of project meetings and typical participants

Meeting	*Participants*
Engineering- and design meetings	Architect Consulting engineer Representatives of technical subcontractors Representatives of the main contractor: Project manager, site manager engineering- and design manager, and selected foremen from main contractor
Progress meetings	Site manager, project leader (only sometimes), foremen, group leaders from main contractor Foremen and group leaders from sub-contractors
Other coordination meetings	Relevant people from contractor and subcontractors; representative of builder; representative of relevant public agencies, etc.

In the second phase of analysis the transcription of one particular progress meeting was singled out for closer scrutiny. This meeting had a duration of 1 hour and 31 minutes, had 9 participants (table 2), and took place in May 2011. Actual construction work had been ongoing for more than a year, which meant that the project organization was fully formed and many routines were well established.

Table 2: Meeting participants

N.	*Role*	*Employer*
1	Site manager	Main contractor
2	Safety manager	Main contractor
3	Forman carpenters	Main contractor
4	Foreman masons / concrete workers	Main contractor
5	Foreman tinsmiths / ventilation workers	Sub-contractor tinsmiths / ventilation
6	Forman plumbers	Sub-contractor plumbing
7	Safety representative (carpenters)	Main contractor
8	Group leader (bas) carpenters	Main contractor
9	Trainee (project management)	Main contractor
10	Researcher	Research group

3.2 Coding and analysis

The complete transcription of the meeting was coded using the software package "Nvivo".[2] The core analytical unit was defined as statements, which could make up one or more complete or incomplete sentences. Statements could be made by one or more people, as sentences could be started by one person and continued by one or more other people.

Exhibit 1: Example of content and structure of generic information loops

Utterances (Participant number, ref. table 1)	***Statement type***
Sequence 1 – adjusting work operations to project plans	
(8) What is to be casted on the 13th floor? (3) That is the small support for.. (2) the floor element put down in front.. (8) Yeah, that's right	Goal statements
(1) Isolation materials [have to be inserted] under wet room cabins, plastic film [has to be] removed	Instruction statements
(1) and the 13th floor remains, [I believe] it maybe still does	Monitoring statement
(1) This is not extremely urgent…	Instruction statement
(3) No, but I think he has… (3) … I haven't heard anything more (2) Has it [still] not been taken care of? (3) I believe it has been taken care of (1) Yes? Under the cabins? (9) Yes, I think so (1)	Monitoring statements
(1) Then [you have to do the] sixth floor on Tuesday. (9) [But] Wasn't everything [that remains of this] supposed to be done at the same time?	Instruction statement
(8) Cabling is ready up there, I could see. On the floor. Sixth floor.	Monitoring statement
(1) Well, then I suppose it will be 6th, 7th and 8ht floor, in one go.	Instruction statement

The coding scheme was developed before and during the data analysis. Coding took as a starting point the theoretical claim from Winch (2010) that the fundamental unit in construction project communication is generic information loops. These encompass instructions to workers, reports on outcomes of operations, and information on managerial decisions. Working with the transcript, it was found that a number of statements could be associated with this kind of information loop. There were statements giving information about goals; statements formulating work instructions; and statements communicating results of monitoring of outcomes. An example of this communicative structure is found in Exhibit 1,

[2] See: www.qsrinternational.com

which contains a brief excerpt from the communication in the meeting. The excerpt is part of the transcrition from the recording and has been translated for the use in this paper.

Observing communication in meetings over a long period of time, it was found that as observers' knowledge of the context (the building project, the stakeholders and the people) increased, it became easier to distinguish nuances and ambiguities in what is being said. Categorization of statements was not always straightforward, as real life statements often had several levels of meaning and had diverse intended effects when looked upon as "speech acts". One example here, found in Exhibit 1, is the point where the site manager states that "this is not extremely urgent..". This was a statement that sounded ironic or joking, and which could be interpreted as a goal statement ("referring to the work plans, this is not urgent"), a monitoring statement ("looking at what is happening on site, this does not appear urgent") and as an understated instruction statement ("this is actually really urgent"). The analysis showed that ambiguities of this kind often were settled in the course of the conversation itself; the dialogue, often in subtle ways, served as a negotiation to settle agreements on the proper understanding of situations and the specific meaning of statements.

One such particular and recurring negotiation was found to concern the general mode of dialogue and indicated the way to what proved to be a powerful extension of the coding scheme: In situations where management would rely on monitoring, goal and instruction statements, other participants in meetings would repeatedly try to pull the discussion in the direction of more open negotiations. In the first case, reference would be made retrospectively to existing plans and the dependencies taken into consideration when planning. Progress was measured against plans, and work efforts *tuned* accordingly. In the second case, meeting participants would consider current and future efforts, and themselves judge on dependencies and to what extent experienced and foreseen dependencies where adequately taken care of.

By scrutinizing the transcribed communication it was found that the latter kind of communication encompassed statements that apparently were monitoring statements, but that in reality were analytical statements that described factual circumstances in order to establish a fundament for problem solving with a degree of freedom from established plans and programmed actions. It was found that very much of what was going on in the meeting had to be characterized as negotiation and problem solving. The communication encompassed factual statements establishing current status (Factual statements), normative statements establishing the desirability of current and possible future states of affairs (Evaluative statements), creative proposals about how to solve problems (Generative statements), statements that aimed at bringing the problem solving discussion to a conclusion (Concluding statements), and sometimes statements summarizing an actual decision (Decision statements). These statements form a different kind of logical structure, or a different type of information loop than the generic loop discussed above (and by Winch). A fragment of communication that illustrates what this kind of information loop could look like is found in Exhibit 2. (Seqence 2 is the immediate continuation of the dialogue rendered in Exhibit 1.)

Exhibit 2: Example of content and structure of complex information loops

Utterances (participant number, cfr. Table 2)	*Statement type*
Sequence 2 – agreeing on priority in future operations	
(1) Well, then I suppose it will be 6th, 7th and 8ht floor, in one go.	
(9) Yes, but then it cannot be completed by Tuesday, I believe	Factual statement
(1) No. Right. That's OK	Evaluative statement
(8) I really wish we could also do the ceilings of the wet rooms at the same time	Generative statement
(7) Yes, in fact, it is not good that they [the electricians] go in and put cables on the floor	Evaluative statement
(7) because then we cannot go in there without stepping on the cables, and then the ceilings have to be left for later	Factual statement
(3) I thought he was not supposed to put cables there before everything was ready	Factual statement
(7) It is not really necessary to do it [the cables] this early	Evaluative statement
(8) No,	Concluding statement
(8) wait with cables on the next level, [it should be made sure] that they don't put the cables in [before the ceilings are ready]	Decision statement
Sequence 3 – agreeing on future safety measures	
(5) There is not so much more work to be done, but the rescue lift and the plan for using it is no longer operational […]	Factual statement
(5) If there is more work to be done high up that requires the use of belts, then we should deal with this.	Generative statement
(4) We need a new plan (9) Yes (8) The lift, yes. (5) The lift and.. (1) Yes, because we have removed that place (8) Yes	Concluding statements
(4) I believe there is a need for an upgrading of the first aid kits, and of the signs are about to [fall down]	Evaluative statement
(4) So I think we should deal with this and make it look a bit more orderly	Concluding statement
(9) I think there are some belts on the roof	Factual statement
(5) This ought to be in order when they start to use belts again	Evaluative statement
(1) Right, we should make a new (3) plan	Decision statement
(4) Yes. And follow it	Concluding statement

Whereas the generative information loops are retrospective in the sense explained above, the more complex information loops tend to be future oriented, and are often concerned with sense-giving, that is with influencing other participants to arrive at a certain understanding of issues at hand. The selected sequences illustrate this.

When coding the material, statements would be associated with generic and complex information loops only if they were uttered in the context of producing decisions. Other things participants in the meeting said where not coded into these categories. This could be statements with a social content such as greetings, content related to personal or private issues, or business issues not related to the ongoing project. To give an impression how much time was used on the different types of communication, a counting has been made of the number of words assigned to the two different forms of communication in the analysis. The results of this exercise are displayed in table 3.

Table 3. Types of communication in meeting

Decisionmaking logic / Statement type	Retrospective sensemaking	Future oriented sensemaking and sense-giving	Decisionmaking communication in all
Goal statements	5,2 %		
Instruction statements	6,2 %		
Monitoring statements	23,8 %		
Factual statements		20,2 %	
Generative statements		7,4 %	
Evaluative statements		4,9 %	
Concluding statements		8,8 %	
Decision statements		2,0 %	
Total	35,2 %	43,3 %	78,5 %

4. Discussion: Sensemaking strategies to rein in construction complexity

Sensemaking is a way of coping with complexity, and retrospective, future oriented sensemaking and sense-giving can be considered as different approaches to reining in complexity. When emergence is accepted as an essential phenomenon in construction, it becomes obvious that one cannot simply rely on pre-made plans and programmed actions to make sure construction efforts progress as desired. Retrospective sensemaking, evaluating current issues in the light of original plans is not in itself sufficient. This has been illustrated in the empirical analysis in the previous section. Managerial decisionmaking based on processing of information from generic information loops is a fact of life in the project investigated. But innumerable dependencies have not been dealt with in the plans, and ongoing operations cannot be regulated only looking at present performance in the light of original plans. Information loops with a different logic from the generic command-control loops have to be established, and information from these loops has to feed into decision making of a different kind. This decisionmaking is of a negotiated nature, and is based on dealing with lack of information and uncertainty by way of future oriented sensemaking, and sense-giving. It seems from the research carried out here that creating a shared sense of purpose and a common frame of reference is very important for this process. Integration and communication across specialty areas is necessary and balancing of bottom up and top down communication on actions and strategies is something that is strived for in the communicative practice in the meeting.

Future oriented sensemaking and influencing sensemaking efforts of others (sense-giving) corresponds to the important strand in the literature on construction and the management of construction projects preoccupied more with creative problem solving, emergence, social relations and on the need for integration of actors and actions in complex project contexts, than with command and control in hierarchical project organizations (Bresnen et al., 2005; Chan and Räisänen, 2009; Cicmil et al., 2006; Gidado, 1996).

As has been stated earlier, this perspective contrasts sharply with the more dominating perspective on project management, which is linear, rationalistic and concerned with

planning, execution and control and commonly associated with the so-called Project Management Body of Knowledge.

Neither of the two approaches ignores complexity, but each of them prescribes a different strategy for coping with it. The basic idea in PMBOK is to structure complexity by way of hierarchical organization, and to base project management on a linear conceptualization of time and of phased development. By defining goals clearly and precisely up front, stages in development can be programmed. In this way, it is distinguished between relevant and irrelevant dependencies, and integration of elements are structured in an economical way; hierarchically and based on a linear timeframe. Project management is tasked with specifying operations and operational procedures, in a way strikingly similar to what was prescribed already by F. W. Taylor about one hundred years ago (Taylor, 2011).

When this approach to building project management is described and interpreted today by a leading scholar such as Graham Winch, the message is that the actual centre of sensemaking efforts is located in the information processing that is an integral part of the command and control function of project management (Winch, 2010). This is sensemaking in the retrospective, Weickian sense. It concerns interpreting past events and comparing them with pre-defined, planned goals, and occurs as part of the monitoring of operational outcomes.

What is shown in the analysis here is that this approach to coping with complexity is inadequate in itself. Many more dependencies crop up during the construction project, and the up-front structuring of dependencies and integration of elements is very far from complete. A lot of time is used by participants in project meetings to establish what the current situation is like, and how it should be understood in the ongoing flow of actions and events in the construction effort. The complex information loops that form the medium for these negotiations embody future oriented sensemaking and sense-giving and depend on participation, collaborative involvement and with balancing bottom up and top down communication in a way that is distinguishing this kind of communication from the command-control oriented structure of the generic information loops.

Looking for what triggers active sensemaking, it is seen that rather than being triggered by chaos, future oriented sensemaking and sense-giving is routinely triggered in situations where project participants perceive complexity to be so high that important cause-effect relationships are opaque for them, and effects of systems events hard to foresee. Active systems integration is carried out in future oriented sensemaking and in sense-giving efforts, and in practice on site; in the active ordering of work efforts.

5. Conclusion

As a strategy to rein in complexity, the traditional management centred approach is pro-active in the sense that it focuses on everything that can be designed and planned up front. But what goes on in terms of sensemaking is retrospective. Building design, project goal setting and organizing are considered to be the outcomes of structured and analytical efforts taking place before the actual building starts on site. Integration is thought to be hierarchical,

with crucial lines of command established in the organization, and with physical elements of the building linked consistently with the hierarchical structure of the project organization. Inter-linkages between subsystems are to be designed at the top level; organizationally by the project management, technically by the architect or designer that establishes the basic template for integration of subsystems.

It is uncontroversial to state that sensemaking is essential in construction and for the management of complex construction projects. But the analysis in this paper has given more controversial results, indicating that the mainstream management centred thinking employing mainly retrospective sensemaking is inadequate. It has not been shown that generic information loops and traditional, top down command and control interactions are irrelevant or non-existent. The analysis has demonstrated, however, that this management approach does not dominate in the particular construction project that has been studied in detail. Rather, traditional management practices exist side by side with a different mode of communicating and of making decisions, particularly in complex situations. Hence, retrospective sensemaking is complemented by future oriented sensemaking and sense-giving, and traditional management is complemented by a remarkably different approach focusing on dialogue and involvement, in the pragmatic efforts to cope effectively with the complexity of coordinating work and making sensible decisions.

What takes place in this case is not retrospective sensemaking aiming at confirming or revising the plans for operations, it is rather proactive problem solving oriented towards the future. Communication encompasses explicit and implicit negotiations, concerning what alternatives ought to be pursued. This communication actively opens up and expands the space for possible outcomes. It does not relate solely to pre-established goals, plans and regulatory frameworks, although these certainly play an important role as factors to be considered in the negotiations. In meetings that work well from a communicative point of view, project management is able to draw on and benefit from the competence and creativity of all stakeholders present at the meeting. In this way, communication is integrating and mobilizing necessary resources to deal with unexpected situations that always emerge in large numbers in the course of construction projects.

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