

Chapter 8 – Teamwork study: aims, context and rationale

8.1 Introduction – aims of the study

This chapter introduces an investigative study that I conducted as part of my doctoral research. The overall aim of this study was to investigate whether, and if so how, communicative networks emerge and develop within a human business context. In this chapter I shall outline the aims and rationale of the study, and introduce some of the pre-existing issues and business contexts that formed its background.

Although this empirical research appears towards the end of my thesis, this actually does not reflect the chronological sequence of events in my research process. I conducted the study in 2001, but the bulk of the *theoretical* work took place after this. The empirical data, and research experience, therefore acted as catalysts for my subsequent theory development, and it was through consideration of the empirical data that I developed the flow-form network model of communication. This practical study therefore serves in this thesis as a set of findings, which can be used to *exemplify* the power of the flow-form network metaphor, rather than as a formal test of the theory.

Business networks have been studied extensively by other researchers. For example, Cheng *et al* (2001) studied the influence of communicative networks within the construction industry, Olkkonen *et al* (2000) made a more general study of communication networks in business relationships, Karathanos (1994) made a study of the state of communication networks when coalitions between organizations break down or become dysfunctional, Ruef (2002) studied how strong and weak ties within business networks can influence innovation, and Stevenson (1993) investigated the nature of problem-solving networks in organizations.

These past studies have, however, all been conducted from a conventional network theory perspective. For the most part, past research on human networks has focussed on network *transactions*, and on networks of *relationships* between people and other entities, rather than on patterns of communicative flow. In this practical part of my research study, in contrast to the transaction-focussed studies of others, I wanted to investigate the

communicative *flows* that emerge as people work together. My intention was to study this on both a macro and a micro level, looking at medium-scale patterns of human interaction, as well as conducting a more detailed analysis of communicative processes. Through this study, I hoped to reveal some of the ways that flow might be encouraged and/or hindered as people work together.

When a flow-form network develops, it is intrinsically connected with its environment - to the extent that a very close relationship between a communicative network and its environment might even be seen as a diagnostic feature of a flow-form network. So, in recognition of this, it was important that a part of my investigation considered how the people engaged with their environment and with the artefacts around them. Questions that needed to be considered included: were artefacts used at all as communicative tools? Did the surroundings of the people affect how they communicated, and if so, how?

As well as looking for communicative network patterns within the system, I was also interested in how the enquiry tools I chose to use might have affected my results. As I discussed in the previous chapter, the methods available for the study of human social systems are not inherently suited to finding flow-form networks. But since they are the only methods available, in this study it was important to choose and use the data-collection and analysis methods carefully, with an awareness of how their application might have affected the picture that emerged.

8.2 The context of the study: Teamwork

Before the start of my research, I already had a connection with a number of different companies who were potential candidates for such a study. The company I finally chose was a steelwork fabricator, of medium size (100 + employees), based in Poole in Dorset. Through working with this company an opportunity arose to study their involvement in a DTI funded construction industry project called "Teamwork".

Teamwork, based in London, had been running for three years, culminating each year in a week-long “Liveweek”, where teams of people from different companies were brought together to work collaboratively on construction designs while co-located in a single large hall (Florence Hall at the RIBA). The exact set-up each year was slightly different. In 2002 (the year when my study took place) a number of informal design teams were each given the task of designing “virtually” a complete computer model of a large building, having regard to all aspects of design, fabrication, erection and use. By the end of the week, the building was to be ready for construction. The Liveweek environment was experimental, and all the buildings were simulated projects, so there was no real building at the end, although there could have been.

8.2.1 Background to the study context – the British construction industry

The Teamwork event lay within the broader context of the British Construction Industry. To explain the basis of Teamwork, which was a new and different mode of working, it is necessary first to describe some of the issues faced by the construction industry in general.

It is recognised within the British construction industry that there are huge problems of communication in major projects, where large numbers of people with different experience and loyalties have to come together for a short time to produce a single unique outcome, a building. This building will then have another diverse set of people who will use it over a long period of time. Large projects, of the sort tackled by Teamwork might involve several thousand people, to include architects, cost estimators, steelwork engineers, heating engineers, site workers, electricians, telephone engineers and so on. A great variety of different components of a building, from structural steel, glasswork, heating systems and so on, all have to be dealt with in an integrated fashion. Aspects such as strength, functionality, aesthetics, safety, as well as its environmental and social impact need to be considered, to name but a few. Such complex projects inevitably incur misunderstandings and errors and a subsequent correction process.

So, the design of a large building, such as an office block, or a theatre requires the coordination of people with many different specialist skills. The various specialists within the industry have been using complex computer models for a long time. Until now, it has not been easy to exchange data between say, the architect's model, the engineer's model and the services model and so on. Solving this interoperability problem has been seen by many as a solution to the industry's communication problems (Auoad *et al*, 1999; Marsh & Flanagan, 2000). Others maintain that improving the technology itself doesn't resolve communication issues, it's more a question of how it's used (Cheng *et al*, 2001).

Studies have already been conducted on communication in the construction industry. Notable examples include Cheng *et al* (2001), who investigated the forms of communication networks that exist within and between construction engineering companies, Sonnenwald (1996) whose study on communication during the construction design process was mentioned in the previous chapter, and Loosemore's (1998) study on communication in construction teams during a project crisis, also mentioned in Chapter 7.

Another topic that is highlighted within the construction industry is how multi-skilled design teams work together, and how the collaborative *design* process is undertaken. For example, Perry and Sanderson (1998) studied the use of artefacts such as drawings and other documents as communicative tools during the design process, while Medway and Clark (2003) have taken a more cognitive approach, looking to identify the thought and language processes that are involved in collaborative construction design.

Teamwork studies have also been conducted within the construction industry context. Austin & Steele (2001) studied how teams work together during the early conceptual design phases in construction, while Sonnenwald's (1996) research on communication roles in design teams includes a study of an architectural design situation. The pervading theme throughout all of these studies is that, in construction the integration of elements such as coordination of design and management tasks, team communication, and communication between people with different skills, is a highly complex issue.

8.2.2 The Teamwork tasks in detail: how Teamwork differed from the conventional approach

The ultimate object for each team at Teamwork's 2002 Liveweek was to design a building. The team members were to create their design collaboratively, dealing with as many detailed aspects as possible; this included architecture, structural engineering, services engineering, quality and cost issues, design of internal fittings etc., as well as design issues relating to erection and fabrication of the building.

The design was to be presented in the form of one or more CAD (computer aided design) models, to as detailed a level as possible. In practical terms this meant designing and integrating a great many component structures, including steelwork, cladding, heating/ventilation pipe systems. Many of these structures require specialist skills in their design, so the project involved collaboration between a number of people with different specialist skills.

At first it might seem that this isn't very different to the tasks and problems that are faced by construction projects in the "real world". However, the difference in the Teamwork approach was that the entire design had to be completed fully collaboratively, with the bulk of the design work being completed in just two days. In normal real life projects this process takes much longer, often weeks or even months. It is not uncommon for designs to be delayed by problems in integrating the different structures. For example, the structural engineers may produce a framework for the building that is later found to conflict in certain areas with the ductwork system designed by the services engineers. One of the risks in real life projects is that these problems might not be spotted until construction on the building has begun, at which point they may be costly and difficult to resolve.

The principle object at Teamwork therefore, was to resolve conflicts and design problems by bringing together and collocating the entire design teams at an early stage in the project to work in an integrated and cooperative fashion. By doing this it was hoped that potential problems could be addressed and ironed out earlier. It was also hoped that the closer working relationships would encourage innovation of novel design solutions.

One of the key features of the Liveweek event was the focus on CAD models and integration of the different IT systems. Many architects and engineers are already used to designing with CAD, but they all use different CAD implementations. Many CAD programs now have the capability of sharing information with other systems, but this is not always attempted in “real life” projects as it can raise some tricky technical issues. At Teamwork it was hoped that some of these issues could be resolved, and that an integrated, multi-faceted CAD model could be produced that incorporated designs from all the different disciplines involved. In addition to this, it was hoped that other computer data, such as cost analysis, and fabrication materials lists could be shared with those who required them for their IT systems. Clearly then it was anticipated that IT systems would have an important role in conveying information between the team members.

8.3 Rationale of the study

One of the first decisions to be made in this study was which parts of the Teamwork process to focus on, and when to collect data. Teamwork consisted of a number of pre-Liveweek meetings and events, and Liveweek itself. The pre-Liveweek events began some months before the Liveweek, and included introductory workshops, team-building sessions and seminars. Each team (there were six in total) also arranged separately to have a number of pre-Liveweek team meetings. At these meetings the design schemes were put together and discussed, the team members’ roles were decided and a start was made on the basic design work.

Liveweek itself took place in June 2002. It was a week-long event, but split into two sessions with three teams in each session. On the final day of Liveweek, a conference was held, where each team was required to give a short formal presentation about their design, and on their experiences at Teamwork.

As a researcher, therefore, I had a number of options with regards to how to study the event. These included:

- i) Studying the whole Teamwork process, from the set-up meetings and pre-design meetings through to the Liveweek event and post-event analysis
- ii) Focussing on a single aspect of the whole event (including the pre-meetings, such as trust networks etc.)
- iii) Focussing on Liveweek

Time and resource constraints prevented me from following the first option, although it was my preferred approach, as it would have given a more complete picture of the Teamwork communication networks than the other narrower fields of study. The second option was too focussed for the kind of network study that I wanted to conduct. Option three was convenient; focussing on Liveweek would provide a concise environment in which to collect data, within a manageable timeframe. It would, however, also be useful to follow some of the activities surrounding Liveweek, in order to contextualize my data. I therefore chose option three, with elements of the first option; I followed the event from the start, attending as many of the pre-meetings as possible, but focussed the data gathering on Liveweek.

In practice, the Liveweek event was to prove to be an ideal environment for the study. Firstly, it was a concise environment, everything was happening in one large room, so for observational purposes it was ideal. Liveweek also brought together new teams for the duration of the event, and so provided an opportunity to observe and record the development of the teams themselves. In the meetings prior to Liveweek the team memberships had not yet been finalised, and there tended to be different people present at every meeting. During Liveweek however, the team membership was much more stable with all of the core members of each team being present. This meant that recognising who was in which team was much easier to do.

The projects and tasks the teams were being asked to do were created specially for Liveweek, and it was intended that they would be brought to design completion within two days. This meant that I was able to collect data that represented the whole of the Liveweek design project, from start to finish, from early design concepts, through to preparation for manufacture. The teams were

required to develop computer models of their design, and networked computers were provided with Internet connections, so the team members had IT connections with each other, and with the outside world. This provided an opportunity for me to observe how design concepts were created and shared using IT, and also how computer technology was used in a wider communicative sense.

The organizers of Teamwork were conducting their own “Knowledge Capture” study during Liveweek that was running in parallel with my own. This meant that I could compare my results with theirs at the end of the study, but also that my role as a researcher was readily accepted by the team members as part of the expected activities of Liveweek.

Finally, and significantly, the use of the RIBA hall for Liveweek meant that no one was on their “home turf”, so that all of the team members were on an equal footing with regard to the work environment.

8.4 Methodological approach

The methods I chose to use for studying the networks at Teamwork were intended to identify whether a flow-form network was in existence, and if so, how the communicative flows were manifested. In the previous chapter I explained how a multi-methodological approach is one appropriate way of using existing analytical methods to investigate a flow-form network. For this study therefore, I chose to base the data collection and analysis of my study on such a multi-method approach. My intention was to conduct a number of different “sub studies”, each looking at communication within the system in a different way. I was to use a different method of data capture and pattern-seeking analysis in each of these sub studies, then to look for recurrences of patterns across all of them. Recurrences of pattern, or correlation between the data sets, would suggest that the patterns reflected an intrinsic flow-form in the system. I chose to apply a three-pronged approach to collecting data, focussing on network structure, communicative content (as manifested in human dialogue) and the system’s physical context (as represented by the use of artefacts, focussing particularly on computer-generated artefacts).

These three aspects were distilled into the following separate, yet interconnected sub-studies:

- Study 1 - The structure of interaction networks between team members
- Study 2 - Dialogic communication in the collaborative design process
- Study 3 - Use of computer-based artefacts as communicative tools

In addition to the three primary studies, I took notes of my own impressions of the event and the interactions that were going on. Although these notes did not contribute directly in the analysis, they proved to be a useful reference when I was analysing the other data. They also added contextual information that proved to be very useful later on in putting the results and discussion into order, and getting my impressions of the data together.

8.4.1 Some practical considerations

The teamwork context was likely to be very rich in potential data, and I wanted to make the most of this. My intention was to collect as much data as possible so that I would have a rich data pool for analysis after the event. I did, however, have to decide what kind of data I was most specifically looking for, and to work out how I was going to gather it.

The organizers of Teamwork had given me a free remit to collect data at the event; provided that I didn't hinder its progress, I was permitted to collect data in any manner I chose. After considering a variety of options, I decided that the simplest and least obtrusive approach was to take a role as "participant observer", joining the event in the capacity of "knowledge capturer". The Teamwork organizers had created a "Knowledge Capture Team", whose primary task during the event was to collect data on its progress, so I took a role as part of this team. So to all intents and purposes I was present as a member of Teamwork, taking part by collecting data on how the event was running. This to me meant observing what was going on and recording data, but not taking part in the design tasks or in the management of the event itself.

8.4.2 Study 1 - The structure of interaction networks between team members

From the outset, I knew that one of the things I wanted to do was to record the interactions that happened at Liveweek, in a way that captured their dynamics and flow-forms. In an ideal situation I would be able to generate the equivalent of a “fungal network map” or “ant foraging map” that represented where people had gone during Liveweek and who they had interacted with. In an ideal world, I wanted to be able to get everyone to dip their feet in some kind of “paint” at the start of the day, so that they would leave interconnecting trails of footprints showing where they’d been during the day.

Obviously the paint option wasn’t possible, so I needed to find alternative methods for tracking the team member’s activities during the period of Liveweek. Methods considered included recording the interactions of the entire population of Teamwork. This could have been achieved by using small cameras or badges that recorded encounters between team members; or it might have been done by videoing the whole event from a suitable vantage point (cameras in the ceiling?), that recorded who encountered who. This, however, presented a problem in terms of how team members would have been identified. Ideas that were suggested included asking team members to wear different coloured t-shirts or hats that identified which team they belonged to.

The notion of recording interactions was given serious consideration, and a number of designs for electronic badges that recorded interactions were postulated. Ideas included infrared detectors in the badges that recorded when they reached close proximity with another badge-wearer, or the similar use of Blue-Tooth technology in the badges. Unfortunately however, none of these methods however proved to be practical, or affordable at the time. Subsequently, a badge has been designed by others that might have worked in this environment (Choudhury and Pentland, 2003).

Eventually, the method chosen to record interactions was to simply observe the interactions that were happening at timed intervals in the hall. The method involved observing and noting at timed intervals who was interacting with whom, and their locations within the room. These data were recorded as maps that showed the various team members' locations and to whom they were near. The data thus produced were subsequently investigated for recurrent patterns using social network analysis, which included analysis using a SNA software package called UCINET (Borgatti *et al*, 2002).

8.4.3 Study 2 - Dialogic communication in the collaborative design process

Study 2 was intended to augment the results of Study 1. While Study 1 would show *where* people went during Liveweek, and with whom they interacted, Study 2 would indicate *what* people were communicating during these interactions; it was designed to capture some of the *content* of their interactions, as represented by their spoken dialogue.

Hand-held video recording was chosen to capture dialogue data. The benefit of using video, as opposed to audio tape is that, as well as recording *dialogue*, videoing also captures body language, and how artefacts such as sketches, computer terminals and so on are used. In contrast to Study 1, which recorded the interactions of *everyone* present in the Liveweek hall, for the video recording I chose to follow just one team. This made the recording simpler, and permitted the collection of in-depth content data. The resultant tapes were transcribed, and analysed for content.

The coding scheme for the Liveweek dialogue data was developed specifically for this study. It was, however, based on an established methodology known as *verbal analysis*, developed by Chi (1997). Verbal analysis is a coding and analysis method for spoken and written data, which seeks to integrate both *qualitative* and *quantitative* approaches. Initially, the data are transcribed, before being "segmented" into utterances, sentences, or other appropriate portions. These segments are then investigated *qualitatively*, and the trends, impressions and patterns that emerge are used to develop or modify an initial coding scheme. This coding scheme is then used to categorize all of the data segments, and finally *quantitative* analysis is used to describe and analyse the results.

The intention in this methodology is that the valuable aspects of both quantitative and qualitative analysis are integrated. So, the *quantitative* analysis is believed to minimise subjectivity, and generate results that are replicable, while the coding scheme itself has been generated in a manner that is intended to engender the *qualitative* trends and impressions that exist in the data.

Lipponen *et al* (2003) have used Chi's verbal analysis method in a situation that was broadly comparable to my own Liveweek study. Their study involved analysing a school class' use of a web-based "virtual" classroom. In a real-life classroom situation, students were given a project to complete, and asked to post information on the project to the virtual classroom and take part in the discussions there. Lipponen *et al* only analysed the data from the web environment; they did not collect any data from the physical classrooms. The data were analysed using both SNA techniques (to measure levels of online interaction of the students), and verbal analysis (to characterise the *content* of the online discussions). The set-up of this study was similar in some respects to my own, in that the researchers measured levels of interaction with UCINET (the SNA software package that I used), as well as characterising the content of the communication with verbal analysis. For the verbal analysis of my Liveweek dialogue data, I therefore chose to start the analysis with the coding scheme that Lipponen *et al* devised. As analysis progressed, however, my coding scheme was altered and adapted to better fit my own data. This process is described in greater detail in the procedures chapter of this thesis.

8.4.4 Study 3 - Use of artefacts as communicative tools

The artefact study was intended to relate the human interactions to *where* they took place, and to the *tools and objects* that were being used.

The data for this study had been collected by the organizers of Teamwork as part of their “knowledge capture” process, in the form of computer files that were collated onto computer CD and copies were distributed amongst the Knowledge Capture team. The CD data included CAD models at varying stages of completion, letters, emails, faxes, scans of sketches, and documentation written by the team members. Also included were screen shots taken hourly from the computers used by the teams, which the Knowledge Capture team had programmed to happen automatically. The major advantage of using these data was that they were being collected anyway by the Knowledge Capture Team, and because I didn’t need to be involved directly in the knowledge capture, this left me to concentrate on collecting the other data. As it turned out, subsequently, I was the only researcher to systematically analyse the data captured by the Knowledge Capture team.

Like the dialogue study, for the artefact analysis I chose to focus on the one team: the same team chosen for the dialogue study. A huge quantity of computer data had also been collected from all the other teams, but it was simply not possible to analyse it all within a reasonable time. Focussing on a single team made the analysis for the artefact study much more manageable. The bulk of my analysis in this study concerned the screen-shot images. Each of these images provided a considerable amount of data, including who was using a particular PC, what computer program they were using, the file they were working on, the time that the image was taken, and so on.

The analysis of these computer files took the form of a basic content analysis. The images were categorised according to what kind of activity they showed, which computer terminals had been used to produce them, who had authored them and so on.

The content data from the image files were compared with and augmented by the other files on the CD’s. So for example, a screenshot that showed a team member working on a particular CAD file was compared with the CAD file itself. Files such as these often have historical data attached to them, including who

authored them, who worked on them and so on. Notes were taken of as many of these details as possible, for later correlation with the network and video data from Studies One and Two.

8.4.5 Integrating the data, comparing datasets, looking for repeated patterns

The data from each of the studies described above were first analysed in a manner appropriate to the data. So Study 1 was analysed using SNA, while Studies 2 and 3 were analysed (separately, using different coding schemes) for content. In carrying out these quantitative analyses, I was looking for *patterns* within the data of each study. In particular I was looking for patterns in the study that reflected flow-form network structures, such as:

- Communicative channels that expanded when the flow through them increased
- Network density (which might be represented by the number of channels or interactions) increasing as a response to increased flow
- Dynamic (or permeable) boundaries between teams
- Creation of cross-links between communication networks to facilitate flow within the network

In practical terms, I was looking for features such as repeated interactions between the same group of people in the network analysis, multiple occurrences of dialogue relating to the same topic or issue in the content analysis, or use of the same computer terminals by different people in the artefact analysis.

After analysing each of the studies independently, an integrated analysis was conducted on the data, correlating and comparing in detail the results from each of the three sub-studies. Here I was looking for patterns that were repeated across different data sets, which would indicate that the pattern was flowing between different modes of analysis, and may suggest flow patterns in the communication itself.

Meanwhile, I was continually reflecting on the methodologies themselves through an iterative process that continually questioned the integrity of the data, and whether the results I was getting were actually representations of what was happening in the network, or whether they were artefacts of the analysis methods. So I was considering:

- Whether the analytic nature of the tools might be causing over-abstraction of the data
- Questioning whether the multiple perspectives were generating a clear picture of the system
- Seeking new ways in which the tools and analysis methods could be adapted to provide a clearer insight into the flow-forms within the network.

8.5 Conclusions

Investigating flow-form networks in a human system was always going to be a challenge because of the analytical limitations of the methodologies available. In this study however, a decision was made to *use* these limitations as an opportunity to see how much one could actually achieve using such methods to study flow-forms. In one respect then, this was to be a study not only about human flow-form networks, but an evaluation of how analytical tools might be usefully applied to studying flow-forms.

In the meantime, it was hoped that by looking for repeated patterns across different kinds of communication data from the system, that I should get an idea of whether communication was flowing between people, their environments, and their tools; or whether the communicative flow was being impeded or disrupted.

The object of all of these investigations was to identify whether flow was at all apparent in the system being studied. Communicative flow might, however, not necessarily be a positive attribute; it could conceivably have a negative or degenerative effect. In this study however, no qualitative assessment was made about the nature of the flow, as this was considered to be beyond the scope of the current research.