Distributed, collaborative design: a focus on information sharing

A University of Strathclyde research project is looking at the role of distributed engineering design in industry. Steven MacGregor describes the project's first industrial case study.

Introduction

The use of globally distributed engineering design teams continues to increase as companies aim to boost profits and decrease lead times by effectively leveraging knowledge and communication from dispersed locations. However, the benefits offered by distributed design are often marginalised by the problems inherent in the process. The following problems have been identified in recent pilot studies:

- Knowledge bases or domains (KB) are 'confused' and 'fragmented'
- KB 'islands' exist internally within organisations and externally within projects
- There is a lack of common under standing between departments and problems with other project partners
- In order to effectively reuse knowledge from past experiences, people have to know that it exists.

The manifestation of these problems has been termed inconsistencies. This seems to be the most appropriate term for factors that cause disruption to the smooth running and understanding of the design process. They arise and are most abundant when knowledge and communication are not used correctly. These beliefs are reinforced by the current industrial climate worldwide. Continual technological advancement is set against a backdrop of international mergers, takeovers and partnerships, resulting in a lack of consistency at the organisational and design project levels.

The Strathclyde University research asks four questions:

- What are the needs of various distributed design teams and their required modes of communication?
- What are the types, levels and location of inconsistencies with in the design process?
- What appropriate knowledge can be used to enhance the design process?
- What are the most efficient and useful methods of integrating and transferring knowledge?

Background

Company A are worldwide market leaders in the production of pressure control and drilling equipment for the oil and gas industry. The main case study site was in Aberdeen, the head office of the organisation's eastern region which includes the UK, Europe, Africa and Russia. The two other main sites are in Houston, USA and Singapore.

This business represented an ideal opportunity for the first case study for a variety of reasons. In addition to the three regional headquarters, Company A has engineering and manufacturing centres and sales/service offices in 59 locations and 24 countries. The work that the engineers do is complex. This technical complexity adds another challenging dimension to the companies distribution and necessitates the optimal use of knowledge. Additionally, the firm has in place world-class systems and people. If problems can be identified in this advanced domain, then they should be applicable on a wider scale.

Methodology

A core team of 10 engineers was involved, whilst informal discussions took place with other employees. The team was asked to take part in semi-structured interviews, complete questionnaires and a daily diary of five short questions for a period of 30 days. These data collection methods were supplemented by other informal discussions and direct on-site observation. All research subjects were either involved in the design process, or in some level of distributed engineering work. The case study lasted for a period of 10 weeks. In total, 21 interviews and 19 incidental interactions took place. This included the core research group of 10, plus other employees at managerial level. This totaled over 130 record sheets and nearly 12 hours of interaction. Twenty-four completed questionnaires and 174 days worth of activity was recorded through daily diaries

Findings

Interviews

The interviews helped in the initial investigation of the main case study issues as well as gaining an important overview of how the company operates. The most important results are:

- The value of reused design knowledge versus the time pressures of formalising all parts of a project. Workers referred to 'a trail of debris' left behind after the bulk of project work is completed.
- The preponderance of variant design within the organisation and concerns about continued practice for the future. Engineers referred to variant design as 'tweaking' of past projects, whilst others voiced their concerns about the 'limited change capability' of certain projects.

Advantages

Each member of the research group could see the benefits in distributed design, citing the following:

- Being able to respond to a global customer base
- Pooling resources, and
- Leveraging experience and knowledge from branches worldwide.

Problems

However, distributed problems, proved as numerous as advantages. Some of these included:

- Distributed team members who do not have sufficient background knowledge and a full grasp of the issues to make informed decisions.
- Team members using abbreviations and acronyms unfamiliar to the rest of the distributed team.
- Duplication of effort worldwide due to a lack of visibility at the other sites.
- Cultural differences.

Questionnaires

How engineers spend their time

Much of the questionnaire addressed the basic concepts of distributed activity and knowledge sharing and how these related to the design process. The following figures show how the engineers spend their time:

- 17.8% of work is distributed
- 36.7% of time is used working as part of a team, and
- 23.3% is spent working with someone from a different discipline.

When asked how often people outside of their immediate location knew about a particular problem:

- Geographically distributed col leagues know more than a co-located colleague 51% of the time, and
- Colleagues from another floor or department know more 57% of the time.

It is important to examine how colleagues interact and increase their design knowledge. It follows that if distributed colleagues know more about certain areas of work and these are not the people who engineers are interacting with on a regular basis, then there has to be some system or procedure put in place which will make up for this apparent shortfall in knowledge transfer. These figures also reinforce the belief that distributed design not only occurs across countries and time-zones, but also within the same site. Indeed, one engineer commented that communication is more efficient with colleagues of a similar background in a different country, than co-located colleagues with a different engineering background.

Methods of communication

Telephone and e-mail are by far the most popular communication tools, followed by fax, videoconferencing and conventional mail (see Figure 1). Mode of communication is perceived as being 53 per cent asynchronous, 47 per cent synchronous, although a large range of answers were forthcoming depending on the individual's role.

Finding information

Encouragingly for the company, the most popular methods of sourcing information were using company systems or asking a colleague in the same office (see Figure 2). Previous studies have shown that personal contact is the most frequently used source of finding information and that 78 per cent of this information was provided from memory. Formally recorded information was comparatively infrequently used and was rarely obtained from formal, maintained repositories.

This shows that Company A have begun to address some of these information management issues. Personal contact is still a primary source of information but company systems were shown to be the most popular. Engineers would then seek a relevant point of contact who would fill in the gaps. These gaps took the form of rationale or justification; in essence, a higher level of design knowledge.

The most useful company systems were those that contained past projects and experiences, followed by those which contained company procedures and policies. The engineers perceived that a third of their time was taken up sourcing or locating relevant information and knowledge.

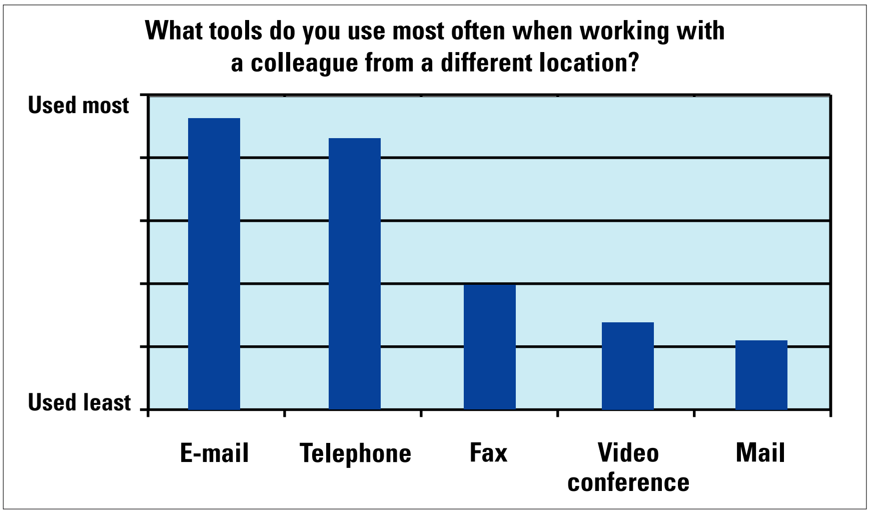

Figure 1

Diaries

An e-mail message was sent from the research base each evening, allowing the engineers to complete the diary the following morning. A typical response to the daily diaries is shown below:

1. Did you take part in any distributed activity (yesterday)? If YES, what was it?

Further attempts to gain information about subsea connectors, eventually being passed on to the correct person, still awaiting details. Received Pro/E simplified model of Company B's template, on to which our tree fits. In exchange, sent them drawings of our tree with dimensions in inches and mm.

2. Did you encounter any problems from this distributed activity? If YES, what were they?

Getting hold of the correct person to get the required information. Company B's Pro/E template model was created in mm, which did not convert very well to inches. The geometry converted, but all reference entities stayed at the original size.

3. Did you take part in any activity which involved the use or exchange of data/information/knowledge? If YES, what was it?

Pro/E model and engineering bid drawings.

4. Did you encounter any problems with this data/information/knowledge activity? If YES, what were they?

As above.

5. Was there any particular piece of knowledge that proved useful yesterday? Details please.

The template model was very useful.

The 30 working days (six weeks) of data concerned distributed collaboration between the engineer on-site in Aberdeen and a sister company in Norway. The teams were working together on a major bid for an upcoming invitation to tender for an oil and gas company in France. The work carried out could be equated to the detailed design phase. The data collection period coincided with the start of the project and continued through to a relatively advanced stage. Initial emphasis was placed on the interactions which took place over the six weeks. The highest level of activity took place with the main collaborating partner in Norway. This accounted for 62.5 per cent of all activity. Next highest (20%) was collaboration with suppliers, followed by other parts of the Company A group at 10 per cent. Subcontractors and customers at five per cent and two and a half per cent make up the rest. This range of collaboration calls for measures to be adaptive to certain situations.

Further analysis of the project was facilitated by examining how information flowed in and out of the Aberdeen site. Instances of information being sent out, information being received and requests for information, both in and out were recorded. Furthermore, when several instances of these occurred over a short space of time, the event was termed information exchange.

The data showed that Information In and Information Out was consistently high over the first two weeks of the project. Requests Out was also high during this period and were sent to sub-suppliers. Closer examination of the interactions shows that this initial period involved gathering all of the necessary 'ingredients' for the design in terms of specifications, pressures, volumes and dimensions. This was followed by a focused period of Information Exchange where the distributed engineers began to conceptualise, after which the initial patterns

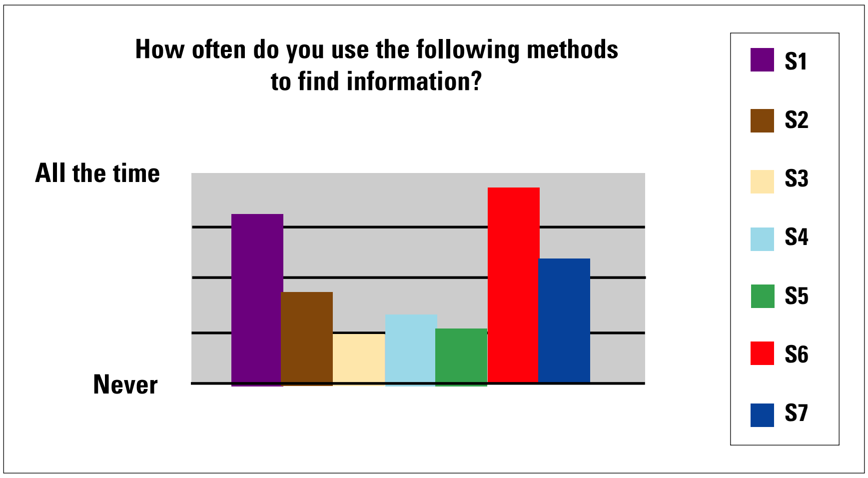

Figure 2

were repeated. This shows cycles of basic information sharing followed by collaborative design - a theme which will be investigated further in the project. Furthermore, asynchronous communication was by far the most common mode of communication. The most popular type of interactions week-by-week were as follows:

- Week 1 – Information In
- Week 2 – Requests Out
- Week 3 – Information Exchange
- Week 4 – Information Exchange
- Week 5 – Information Out
- Week 6 – Information Out

Further studies on the linkages between these information interactions as well as the objects and entities they refer to are required.

A series of problems were also communicated during this sample activity.

Week 1
Design indecision
Use of unfamiliar abbreviations and acronyms
Not knowing who to contact for information
Unachievable design detail.

Week 2
Misunderstanding during call
No reply/response (two instances)
Getting hold of correct person for information
Geometry conversions from metric to imperial.

Week 3
Ill informed design changes
Poor distribution of information
Misinterpretation of e-mails.

Week 5
Describing and interpreting
Poor distribution of information
Ambiguities.

Week 6
Disagreement
No reply/response
Colleague with important information absent.

Obviously, some problems are human based and will occur during any collaborative or work activity, regardless of distribution. However, others such as the problems with abbreviations and ambiguities may be solved by making best use of the design knowledge abundant in the work activity. Others, such as disagreement with the design, are compounded by distribution, making it harder to come to an agreement. These problems may be split into the 'taskwork' and the 'teamwork', or the work of working together.

Summary

The findings have increased the understanding of distributed design by profiling its use in industry and some current problems which need to be addressed. The findings have also begun to address the overall aims of the project.

- What are the needs of various distributed design teams and their required modes of communication? – Perceptions of distributed design have been communicated through the interviews and questionnaires while the diaries have shown a live project. For example, the diaries have shown that asynchronous communication is more prevalent and the information profile charts have addressed the needs of engineers at different stages of collaboration.
- What are types, levels and location of inconsistencies within the design process? – A series of problems relating to distribution and knowledge have been communicated in all the methods. Problems of ambiguity and misinterpretation communicated through the diaries may lead to inconsistencies if they are not continually checked and confirmed;
- What is appropriate knowledge that can be used to enhance the design process? – Knowing where engineers get their information and knowledge from, as shown by the questionnaires, will enhance understanding of appropriate knowledge.
- What are the most efficient and useful methods of integrating and transferring knowledge? – Further analysis is needed.

Further work

The findings to date address the overall aims and objectives of the project. However, further material from the case will augment the present results. This will come specifically from an additional in-depth analysis of the daily diaries undertaken from a different perspective.

The medium term will see the completion of a further case study that will enable a different perspective on industry and enable the required cross-case analysis. One element of focus will include the identification of types of inconsistencies within the distributed design process. Finally, the medium to long term will include some form of prescriptive solution in response to this descriptive phase.

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