Kristin Lofthus Hope

New Knowledge Objects ?

Exploring Cultures of Representation in
Knowledge-Intensive Work

Doctoral thesis
for the degree of doctor artium

Trondheim, September 2006

Norwegian University of Science and Technology
Faculty of Arts
Department of Interdisciplinary
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Preface

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Bergen, February 2006

Kristin Lofthus Hope

Contents

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New Knowledge Objects? Exploring Cultures of Representation in Knowledge-Intensive Work

The study of science and the study of knowledge

The ZKM (Zentrum für Kunst und Medietechnlogie) in Karlsruhe, Germany, has created a new exhibition called 'Making Things Public. Atmospheres of Democracy'.[1] The Internet presentation of the exhibition stressed that it addresses the challenge of renewing politics by applying to it the spirit of art and science. A previous exhibition in 2002, Iconoclash, dealt with representations in art. The 2005 exhibition drew on Iconoclash, although the problems of representation in politics were the main issue. It was considered as a goal the re-exploration of the term 'politics' and what actually constitute politics. The main point was to explore how we look at things in relation to other things, which is an interesting question when we are eager to re-explore old notions that seem to be dead and devoid of content. Culture is another notion packed with various articulated or non-articulated substances. Therefore, it is also important to re-explore this notion and find out more about what constitutes culture, with aware of its vagueness.

This dissertation addresses questions that are different from - but still related to- those presented in the Iconoclash exhibition. My concerns have emerged from an analysis of cultures of so-called knowledge-intensive work, which may be defined as the supply of services based mainly on a workforce of university-educated employees. The goal has been to contribute reflections about the culture of knowledge-intensive work, above all the under-communicated material aspects. I set out to explore how knowledge is produced and performed in knowledge-intensive organizations, applying a 'work culture' perspective. My intention was to investigate the everyday life of knowledge work and knowledge workers.

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[1]From the internet- site: http://on1.zkm.de/zkm/stories/storyReader$4581, June 10th, 2005.

After a while, I became increasingly curious about the way knowledge workers and their knowledge products were represented outside their texts, drawings, presentations and programmes. One set of issues evolved when reflecting on the critique of science studies, which saw scientific knowledge as disembodied (see, e.g., Traweek 1988, Lawrence & Shapin 1998). When one starts to think about knowledge as embodied, this raises questions about how knowledge may be housed and dressed. Alternatively and more precisely, are there interesting observations to be made about the architecture of workplaces and the dress codes of knowledge workers, as well as the extent to which these may be interpreted as representations of knowledge, knowledge work or knowledge workers?

Another set of issues came from discovering how the performance of knowledge work was influenced by the kind of representations of such work found in marketing, contracts, and project management tools. What kind of representations could be found, and how did they affect the actual process of producing knowledge? Thus, my research questions changed from a rather open-ended set of inquiries about the culture of knowledge-intensive work to an interest in describing and analyzing the production and performance of various forms of representations of such work. Of course, this is an aspect of the broader set of concerns related to the cultures of knowledge production. In this introduction to the four papers that constitute the empirical core of my dissertation, I want to introduce some potentially useful frames of understanding such issues, in order to provide the groundwork for some cross-cutting observations from the four papers.

As indicated, my general focus is on the characteristics of different types of work culture in various knowledge-intensive organizations that supply consulting services. The notion of 'knowledge-intensive organizations' has been used to characterize companies that depend mainly on abstract knowledge to provide their services (Nelson and Winter 1982, Drucker 1993, Alvesson 1995). A consequence of the interest in the 'knowledge-centred' discourse has been the growing concern about organizational learning and knowledge cultures. The latest addition is the attention given to knowledge management (Nicolini, Gherardi, and Yanow 2003). However, what 'knowledge-management' means is a complicated question with many lines of inquiry, according to Fuller (2002).

As Knorr-Cetina (1997) emphasizes, the traditional definition of a knowledge society highlights knowledge as a specific product. This definition is often used in the knowledge-management literature. The introduction of the notion of knowledge-intensive companies is an extension of the knowledge society concept. Although knowledge has always been important in any work, the new direction is that knowledge in itself has become an object outside an academic context. As Fuller (2002:2) rightly claims, the composition of the word ‘knowledge’ with other words like firm, society or management is what rhetoricians call a catachresis. This involves the strategic misuse of words, used as a euphemism for something unsavoury. All the same, to combine ‘knowledge’ with ‘company’ is a way to describe some of the main features of an industry that delivers services and products that are mainly related to the employee’s knowledge. Examples of professions related to knowledge businesses are various types of consultants, researchers, and consulting engineers.

Similarly, the concept of ‘culture’ has many connotations. The creative ‘misuses’ of the concept range from the arts to the design of corporate cultures. For example, Mats Alvesson (1993) distinguishes between four different perspectives on organizational culture. Starting out with the big picture is to view the organization as one culture with unique and unitary characteristics. The second approach is to examine the organization as a meeting place for various fields or cultures, which interact as one common overarching culture. The third, the local perspective, highlights organizational subcultures, while the fourth sees the organization in terms of different cultural figurations (Alvesson 1993:108). My challenge at this stage is not to choose the right or best of these perspectives, but rather to point to the myriad meanings ascribed to culture. For example, within the corporate culture approach we find pragmatic as well as instrumental purposes that provide a restricted meaning that may not be very helpful when mapping a work culture. Here, I want to start out from a rather open conception, where the aim is to identify and characterize the variety of patterns of actions undertaken in various settings, rather than interpret this as an expression of a particular, more or less well-defined culture. The goal will not be to define a new concept of culture, but to use a generic version to frame and guide the discussion.

A main frame of understanding in this dissertation is the field of science studies (Collins 1985, Latour and Woolgar 1986, Bijker, Hughes, and Pinch 1987, Traweek 1988, Sørensen 1998, Knorr Cetina 1999, Forsythe 2001, Law 2004). However, the use of this frame of understanding to analyze knowledge work in non-science settings is not straightforward. Currently, there are several concepts that emphasize changing ways of producing knowledge inside and outside of science. These include triple helix (Leydesdorff & Etzkowitz 1997), post-normal science (Funtowicz & Ravetz 1993) and Mode 1/Mode 2 (Gibbons et al. 1994, Nowotny et al. 2001). Elzinga (2004) and Shinn (2002) have criticized these concepts for being too vague, but possessing huge rhetorical power. For my purposes, their suggestiveness is useful in providing a canvas wherein production of knowledge is presented in quite diverse, but still related, ways. This provides support for the use of the science studies frame in the analysis of knowledge production in non-science institutions.

In addition, they represent conjectures about changes that are important to my inquiries. For example, Mode 1 is employed to summarize in a single phrase the cognitive and social norms of the traditional academic production, legitimation, and diffusion of knowledge (Gibbons et al. 1994). Homogeneity, disciplinarity, and preservation of form are characteristic of Mode 1, in addition to a specialized and disciplinary science. Supposedly, Mode 1 is loosing terrain to Mode 2 knowledge production, the latter being more heterarchical, transdisciplinary, and transient. Mode 2 practices are more socially accountable and reflexive, and in addition are temporary and heterogenic. In addition, when collaboration came into being, the problem of collaboration is defined in a specific and localized context. In Elzinga's opinion, the real strength of this metaphorical description is its success in reducing, integrating and re-describing a complex reality, thereafter mobilizing various actors to take this account of reality at face value.

My intension has been to observe knowledge-intensive work in practice. However, such practices include interaction with objects that may be material as well as non- material. Knowledge objects include matters used consciously as well as unconsciously during knowledge production. My goal has been to extend the understanding of what these objects are, and later on I will discuss some examples.

A critical issue in the pursuit of my research questions is what it means to talk about science cultures or knowledge cultures. To begin with, it should be noted that the traditional theory of science ‘others’ the role of culture in the analysis of science, placing it beside the ethos of science that is presumed to nullify the impact of outside culture. This is eminently described by Merton (1942), particularly in his norm about universalism. The North American anthropologist Sharon Traweek (1988) ironically characterizes a widespread perception of science as ‘the culture of no culture’. Thus, to analyze science as culture has been a radical but necessary move to allow us to investigate science empirically.

However, this may lead in quite different directions. If we juxtapose the efforts of French sociologist Pierre Bourdieu and Sharon Traweek, we gleam insights into two ways of doing such cultural analysis. To begin with, their views of and approaches to science are quite different. For example, Bourdieu’s (1992, 1996) interpretation of how the intellectual field functions is based on his concepts of habitus, field, and cultural capital. To have a too close or a very distant relationship with the field can be problematic. It is risky to become less objective when studying one's own profession, as Bourdieu does, but he claims that it is possible to do so when using scientific tools to objectify the social world. On the other hand, Traweek's (1988) starting point is to mould into the culture of science by studying the everyday experience of the high-energy physicists though ethnographic fieldwork.

Bourdieu's approach to the scientific field is to claim that it is a field like any other social 'field'. This implies that diverse power relations, struggles, monopolies, interests and profits are enacted, although these invariants take special forms in the intellectual field (Bourdieu 1992, 1996). It is possible to use the sociology of science as an instrument to uncover the social boundaries that have an effect, through either external or internal limitations. Bourdieu stresses that there exist limitations in all different social fields, noting that in the academic field there is a widespread illusion of being free. Within the academic field, it is also possible – and beneficial – to mobilize the social capital one possesses and Bourdieu underscores that the position one has within the field will be defined from one's own dispositions and positions.

Bourdieu's notion of the academic is relational. The academic will only be an intellectual in relation to others or something other. Bourdieu's investigation of the academic elite in France is an effort to show how the academic field is characterized by the employment of cultural capital and how academics with a good deal of social capital dominate, therefore tending to reproduce existing power relations. His focus is on the systems that make up the academic field.

Traweek's (1988) mapping of a specific academic area, the world of high-energy physics, provides a contrasting image:

> I have presented an account of how high energy physicists construct their world and represent it to themselves as free of their own agency, a description, as thick as I could make it, of an extreme culture of objectivity: a culture of no culture, which longs passionately for a world without loose ends, without temperament, gender, nationalism, or other sources of disorder – for a world outside human space and time (Traweek 1988:162).

The everyday experience from the field was the main data source for Traweek. Through her ethnographic analysis, she discovered how the high-energy physicists' saw their world, created a working academic field, and educated physicists, as well as how the research community produced knowledge. The investigation focused on three different laboratories, two in the US and one in Japan, also exploring the role of gender and national culture. In Traweek's interpretation, the physicists saw their profession as one of discovery, where they guarded the fundamental truth about life on our planet. Their privileged role in society reinforced this belief. Their discoveries had an aura of mystery. The physicist's revealed hidden facts, which were presented to the public as stable and concise information. Traweek (1988) claimed that the cost of high energy physics research only reinforced its assumed cultural value, pointing to the enormous expense of constructing and running the large accelerators, free from cost-benefit analysis.

To interpret the culture of high energy physics Traweek unfolded different cultural phenomena within the laboratory. The result is that the physicists become a part of what they produced. Traweek provides the reader with a thorough description of the social organization, developmental cycles, training, and the material culture of the three laboratories. Traweek's account provides a narrative of the process of producing knowledge within the high-energy physics community. She claims that the detectors were the main informants in the study because they were the materialized objects in which physicists or their knowledge culture met nature, where knowledge and passion became one (Traweek 1988).

The physicists designed their detectors to measure nature. Thus, the detector became a symbol of a particular interaction between technology and humans. To read the detectors as text made it possible to tell a story about the culture of high-energy physics, and from that reading Traweek describes the reproduction of nature, the construction of discovery and the reproduction of physicists in their community (Traweek 1988:161). Her symbiotic analysis of technology and culture adds a new understanding of the culture of knowledge or science as one of many fields to study. Science is only one of many sites for the local understanding of culture.

Both Bourdieu and Traweek study knowledge workers, even if they do not use this term, but they have rather different interpretations of how and what to study when analyzing intellectuals. Both show us that science and, more generally, the making of knowledge may be studied as empirical phenomena. Bourdieu underscored that science is very much a part of the whole society and is not only related to the academic community. He stirred up academics in France by arguing the importance of cultural capital to the performance and outcome of intellectual work. Traweek, on the other hand, provides a much more detailed understanding of the culture of producing knowledge in high-energy physics than Bourdieu does, with his much broader analysis. Traweek notes how high-energy physicists see themselves as elites, but she is more concerned with the inner dynamics of the community than with their larger social role.

With respect to my research questions, Bourdieu and Traweek would provide distinctly different research strategies. From Bourdieu's perspective, my concerns would need to be reframed; for example, in terms of social capital as an external force that shapes the representations of knowledge work and knowledge objects. Since class structures are less prominent in my field of interest, Bourdieu's perspective will not be of current interest. I have chosen instead to pursue the perspective offered by Traweek, which facilitates analysis of the kind of representations I want to study. Above all, her investigations into the role of detectors in the work of high-energy physics are suggestive of the way that knowledge objects and representations interact.

To analyze my research questions, the frame of understanding offered by science studies needs to be made clearer. I will also discuss some alternatives that may offer useful supplements. However, in order to inform the reader about the empirical terrain of the dissertation, I will briefly present summaries of the four papers.

An overview of the dissertation

In addition to this introductory chapter, the dissertation consists of the following four papers:

1) The Architecture of New Knowledge Factories: A Mode 2 Design?
2) Dressing for Credibility? A Study of Accounts of Dress Codes in Norwegian Knowledge-Intensive Companies
3) Configuring Designers? Using a Project Management Methodology to Achieve User Participation
4) Testing Computer Systems: Code, Customers, or Contracts?

Paper no. 1:
The Architecture of New Knowledge Factories: A Mode 2 Design?
Embedded in the construction of buildings, there are many unspoken and barely perceived assumptions about production, consumption, and other forms of social, economic, and political behavior, among other things. A great deal is tacit and taken for granted in the design, use and shaping of buildings. Therefore, the field needs to be studied more, especially from a science and technology perspective.

If society is moving in the direction of knowledge production in line with a Mode 2, transdisciplinary situation, I would expect a new form of architecture for knowledge production. Different co-operational practices would require a new architectural design; for example, an architecture that could make communication easier and make co-operation smoother. The characteristics of these new trends have been flexibility, teamwork, network, cooperation, but the question is how these changes will materialize themselves through architecture. The point is not to tell generally how one is doing office design today, but to discuss the materiality and contextualization of the Mode 2 notion.

In a business world where knowledge production occurs, Nowotny et al.'s (2001) assumption about the contextualization and robustness of knowledge through a transdisciplinarity that extends to hybrid forums where experts and non-experts interplay in the shaping of knowledge, does not function to its full extent when there is restricted access and openness to the various process going on. The materialization of both Modes 1 and 2 in the various office buildings studied reaffirms this point. The architectural design is more ambiguous than the Mode 2 approach suggests.

Paper no. 2:
Dressing for Credibility? A Study of Accounts of Dress Codes in Norwegian Knowledge-Intensive Companies

The paper explores dress codes and knowledge workers' perceptions of dress codes related to their work. Do dress codes have any bearing on the authority of their knowledge, or is this a superficial phenomenon without any real relationship to the production and implementation of knowledge?

In the paper, I have discussed three main sets of questions regarding the way knowledge workers dress. One is related to the issue of trustworthiness and the potential role of clothes as modalities of expertise and factual propositions. For example, is it important to display ascetic behavior or authority to become trustworthy? The second is about the role of clothing to the quality of working life of knowledge workers and the potential relationship between informal dress codes and creativity. The third is related to the multifaceted performance of knowledge workers and the relationship between diverse front stages and the backstage in their everyday work lives.

Appearance was important as a communication device for most of the consultants and researchers in the study. They believed that clothing was important to the way they were perceived and thus to their credibility. However, it should be noted that this need to 'dress for credibility' is mainly felt when they wanted to communicate outside their group of peers, such as with clients. Clothing seems to be important when performing ‘public proofs’, and less so when trying to persuade peers.

Thus, knowledge workers do not primarily dress for credibility. Their dress code is developed in a complex situation where there is an issue of credibility related to non-peer communities, like clients, but at the same time a concern for comfort and creativity related to the actual production of knowledge. Probably, most knowledge-intensive companies manage this complexity like the hybrid companies in this study: by differentiating between dressing for front stage performances usually related to meeting clients and similar actors and for backstage performances related to peers. However, it is interesting to note that some companies may choose to act as if all the world is a front stage, while others seem to be allowed to dress for a life in a more protected setting. Dress codes may, on the other hand, be read as representations of the culture of producing knowledge.

Paper no. 3:
Configuring Designers? Using a Project Management Methodology to Achieve User Participation

The third paper revolves around user participation in system development. On many occasions, it has been observed that it is important to foster a democratic design where in which users participate. Improved information from users reduces the risk of building a computer system that does not fit their needs. In addition, participating users are more likely to claim ownership of the computer system and be helpful in implementing it.

However, achieving more productive user involvement has proved difficult. Different methods have been developed to facilitate such participation. The paper analyses the use of one such method called ‘The Dynamic Systems Development Method’ (DSDM). DSDM aims to secure user participation as well as improve other aspects of project management. The goal of the paper was to examine this claim by analyzing the ability of the method to enforce user participation in design. To study the use of this method, we participated in two different system development projects in a Norwegian software company named Calculus.

The study revealed that a system development method would not in itself secure user participation. It may act as a tool of control in development when choreographed properly by project management, but the need for such choreography is not suggested in the method. The iterative element in the DSDM method does not extend beyond the small components in the development phase. There were no such elements regarding time, contract, and budget for the development.

DSDM offers tools to provide an arena where enrolled users can learn how to communicate with software engineers. However, DSDM and the technology chosen as the basis of the system act as obligatory passage points throughout the system design. Since DSDM only allows technological communication, this situation makes technology the hegemonic basis of interaction.

The relationship between users and software engineers observed in Calculus was not as fluid as Mackay et al. (2000) claimed. In fact, the relations between software engineers and users were quite fixed from the start in both projects, due to the implicit hegemony of technology as the basis of communication and evaluation. To improve user participation in system design projects, one needs new ways to talk about work as well as computer systems.

Paper no. 4:
Testing Computer Systems: Code, Customers, or Contracts?

This paper focuses on the testing of software. When a system is tested, it is in a kind of limbo while the workability of the system is investigated. Systems are supposed to work after a test, but the notion of a workable system is not clear. What happens when computer software is tested? The technology is put on trial, but testing occurs in a social as well as a technological context, and may involve different views of what is to be revealed during testing, and what it means to claim that a particular piece of software is working. Consequently, testing may be quite complex and even create conflicts between different parties involved in software development.

Therefore, this article analyzed such complexities of testing by analyzing activities undertaken in a Norwegian software company when they tested the results of months of development work and interaction with users. The paper explored the performance of testing and the relationship between testing and software development practices more generally. It was based on a field study of a large project called Nest, which took place at Calculus, a mid-sized Norwegian system development company.

It was the rather simplistic, rationalist preconceptions of the specifications in the contract that provided the real terms for the development efforts in the end. The specifications of the contract represented a strong force that reshaped the effort to make the system development iterative become quasi-linear. In this paper it was revealed that the contract was a steering document for development, and was more important for claiming a workable system than previously assumed.

Epistemic machineries, material knowledge objects and the work of representations

> It would be nice to be able to define what is specific to our modern scientific culture (Latour 1986:1).

The borders between scientific and other cultures is merely as boundaries of otherness. Latour remarks that these divides are helpful for contrast, but they do not provide any useful explanations and therefore need to be explained. His answer is to let go of the grand dichotomies without becoming a relativist, who would only highlight a few simple differences between science and other fields. Examples of materialist explanations are infrastructure, markets, or consumer needs as accounts for science and technology. End products like the ‘market’ or the ‘economy’ cannot explain or account for science. Culture would also be in this category of end products. Star (1995) shows the problems of using this notion:

> Culture is a word like society, with a number of unfortunate definitional and philosophical problems associated with it (Star 1995: 26).

Star’s point is that often the notion of culture is used to create monolithic stories to describe a society, when really the story is much more complex. Her goal is to turn the understanding upside-down and use the term ‘culture’ to draw attention to the multiple, non-monolithic sense of talking about a set of practices with symbolic and communal meaning. However, could we try to answer Latour’s question and join it with Star’s set of practices? What if we look into different constituent parts regarding science or other knowledge producing business fields, and describe sectors that create and warrant knowledge?

The aim in the dissertation was to address a related set of questions that have emerged from the study of cultures of knowledge-intensive work. One aspect that has been interesting about such cultures is the various representations of knowledge work and knowledge workers, matters that often are not discussed. I have been particularly interested in the design of workplaces and the dress codes of knowledge workers. What is performed through such objects? Another set of questions is related to the way knowledge work is influenced by representations of such work found in marketing, contracts, and project management tools. What kind of representations could be found, and how do they affect the actual process of producing knowledge? Thus, my research questions evolve around a concern for describing and analyzing the production and performance of various representations of knowledge-intensive work.

To discuss knowledge production and representations of knowledge-intensive work, I will use three different concepts: epistemic machinery (Knorr Cetina 1999), knowledge objects, and representations of materiality (Lynch and Woolgar 1990). These concepts have been chosen to illuminate insights concerning representations of knowledge-intensive work. My goal has been to contribute to reflections about the organization of knowledge-intensive work and its under-communicated material aspects.

Epistemic machinery

To map the way knowledge is represented by social and material relations, it is helpful to draw on Knorr-Cetina's definition of epistemic culture and her focus on different parts of the machineries of expert systems:

> Epistemic cultures are cultures that create and warrant knowledge, and the premier knowledge institution throughout the world is, still, science (Knorr-Cetina 1999:1).

The goal is to increase knowledge about the machineries of contemporary sciences, to make it possible to see the larger picture of technical, social, and symbolic dimensions of intricate expert systems. Knorr-Cetina's focus is the construction of the machineries of knowledge construction, which is different from traditional notions of knowledge production. The epistemic machinery would reveal the fragmentation of contemporary science and hence the diversity of epistemic cultures (Knorr-Cetina 1999:3).

However, it is not only within science that it is possible to reveal the various systems for knowledge production. Therefore, to study other organizations that deliver products based on employees' theoretical expertise would present the possibility of broadening this perspective even further; for example, to study knowledge-intensive companies that deliver intellectual services according to clients' specifications (Alvesson 1995; 2001). The companies in my study are knowledge-intensive enterprises that deliver products and services based on the theoretical and practical knowledge of the employees. However, it is important to bear in mind that: '*The idea of knowledge-intensive companies and related concepts such as knowledge work is problematic*' (Alvesson 2001:864).

However, the categories are problematic, as is the task of distinguishing these companies from less knowledge-intensive enterprises, especially since the performance of all kinds of work involves the use of knowledge. In spite of these visible weaknesses, Alvesson maintains that it is meaningful to refer to knowledge-intensive companies. Nevertheless, one has to be aware of the vagueness of the category. To use the notion of epistemic machineries in the analysis of these companies could hopefully reveal mechanisms helpful for outlining the bigger picture of their epistemic culture.

Knowledge cultures consist of the whole set of structures and mechanisms that relate to knowledge and also give details about its communication. Epistemic cultures are about how we know what we know in any given field. Knorr-Cetina was concerned with knowledge as it was practiced and unfolded within structures, processes, and environments that build up specific epistemic settings. This approach is multidimensional and could be contradictional as well. To continue with her definition of culture:

> Culture, as I use the term, refers to the aggregate patterns and dynamics that are on display in expert practice and that vary in different settings of expertise. Culture, then, refers back to practice, in a specific way (Knorr-Cetina 1999:8).

Her main point is not related to knowledge practice but to the vast amount of machineries installed and their construction in knowledge production. Therefore, epistemic cultures are important cornerstones of so-called knowledge societies. The analysis is described as a kaleidoscope, where a succession of conjunctional activities shifts the focus in the analysis. The goal was to provide a kaleidoscopic view of empirical-, technological-, and social- machineries, although the combination of the various patterns will not be 'all-inclusive' for the local practice (Knorr-Cetina 1999:24). Everything- people, symbols, and objects- becomes epistemic devices in the production of knowledge. One of the goals was to make visible the complex texture of knowledge as practiced in modern institutions by enlarging the notion of what to study when studying knowledge, calling it epistemic cultures.

Knorr-Cetina highlights that epistemic cultures seem to be a structural feature in knowledge societies. It is not the whole story, but it is possible to understand elements to learn more. To study the culture would be to gather different practices and preferences that would reveal their special characteristics in relation to one other. This is the starting point for empirical studies, but it would also be important to reveal symbolic aspects about modes of living. According to Knorr-Cetina (1999:247), the sociological understanding of culture emphasizes too many different norms and values, forgetting the symbolic and meaningful aspects of modes of life (Geertz 1973). Therefore, an interpretation of the various existing meanings is neccesary. Through the ethnograpical method it is possible to see the production of knowledge as constructive rather than descriptive (Knorr-

Cetina 1995). However, it is useful with various methods to reveal the underlying structures of a special field, and especially to combine methods to expand the perspective.

Scientists and other experts are integrated parts of the construction of the epistemic systems. Therefore, the applied researchers and software engineers studied thorughout my dissertation can also be considered as parts of the epistemic system. The epistemic systems are not built alone by one actor; instead, there are many actors involved in constructing a system. The epistemic or the knowledge foundation will be derived from these systems, wherein the symbolic struture is seen through the definition of unities, classification systems, the epistemic strategies, and empirical procedures. The various structures and systems form the foundation for the practice of knowledge work, and therefore it was important to have a varied focus during the data collection that formed the empirical study.

I concentrated my attention on the everyday work experience within the context of the knowledge-intensive companies in the study. These companies differ from other organizations because of the relative importance of organization for project workgroups. The project groups carry out the actual assaignments within a given time and with limited resources (Eskerod and Östergren 2000). Therefore, the project level in the organizations has been important to the study.

In Knorr-Cetina's (1999) study, the notion of collaboration was understood within two research entities. The goal was to reveal the systems used in knowledge production. Her argument underlined the importance of systems for knowledge production, focusing on the system level. Knorr-Cetina claims that previous research had been too preoccupied with single actors and also focused too much on single explanation variables. Examples of such variables are power relations, rhetoric, economic relations, laboratory decisions, and research communications. Latour and Woolgar (1986) and Traweek (1988) have been criticized along these lines, even if both studies showed the importance of extending the view of the laboratory context, taking more factors into consideration when analyzing the work of scientists or knowledge workers. However, it is not easy to take a holistic view when analyzing a work premise because there are so many factors involved. Thus, it may be fruitful to focus on particular aspects, not to explain but to explore knowledge cultures. Consequently, the papers in this dissertation pursue the role of dress codes, office design, standardized methods for project work and software testing, respectively. Presumably, these are important and interesting elements of such epistemic work systems, which may help to broaden our perspective.

Knorr-Cetina claims that the patterns shown in her study can be used as illustrative features of or as templates for other studies so that the distinctive features of her analysis can be compared to other expert domains or serve as pointers to other dimensions. She wanted to explore the limitations of knowledge by using ethnomethodology to unfold, frame, and convolute knowledge to see how other knowledge cultures are configured (Knorr-Cetina 1999:252). Knorr-Cetina claims that her focus was on the producers of knowledge as diverters of knowledge, analyzing practices grounded in both epistemic subjects and objects. Her goal was to broaden the view of what constituted the studied field.

One answer then may be to study the construction of the machinery of knowledge production, and not only the production of knowledge. In a way, epistemic machinery is a common term representing all the various constituent elements within knowledge production, such as institutions, institutional practices, devices, methods, identities, dress codes, and office design. Knorr-Cetina maintains that conventions and devices are organic, dynamic, and thoroughly considered. However, to study all the components of the various part of the machinery is not possible because of the complexity involved. Rather, one has to look at some aspects of the overall machinery. Still, a focus on epistemic machinery can bring out the diversity and disunity of epistemic cultures (Knorr-Cetina 1999:3). The goal is to enlarge the knowledge machineries of science until it is possible to see the myriad technical, social, and symbolic dimensions of expert systems. This is a useful approach, and perhaps the various machinery elements from this dissertation can contribute to a further enlargement.

Importantly, Knorr-Cetina insists on the disunity and the fragmentation of the sciences, scientific methods, and some specific ontology of instruments. She points to the different markets within science where independent epistemic monopolies produce very different products, providing insights into the epistemic disunity of contemporary natural sciences in their machineries of knowing. In Knorr-Cetina’s opinion, previous research has focused too much on action driven practices, overlooking the processes that include the machinery of knowing that are composed of practices. In addition, it was important to bring in sensitivity for symbols and meaning to enrich the idea of epistemic machinery (Knorr-Cetina 1999:10). Therefore, when we open up the epistemic machinery notion, it contains practices, but symbols are important as one backcloth of practice. The machinery concept brings in an aspect that goes beyond the epistemic individual and focuses on a level above the individual, thus providing a fuller description of the epistemic culture.

The machinery notion is useful to discuss many different aspects of the kind of contexts that I have studied, to point to diversities within a knowledge production process. For example, the various methodological approaches applied in a knowledge-intensive service context are one part of the machinery to produce, establish, and realize knowledge. According to Amdahl (2005), various methods for carrying out projects will primarily have a beneficial effect if choreographed or staged with reference to the context where they will be utilized. Carlsen (2005), on the other hand, shows how everyday work practices in such companies are charged with questions about identity and situated authority actions. He uses the term ‘becoming’ to express the process of company development, which also involves collective fields of meaning and engagement. This study points to the production of identity as a part of the epistemic machinery.

Buildings and the design of the work environment is the focus of the paper ‘The Architecture of New Knowledge Factories: A Mode 2 Design?’ Here, variations in the design and organization of the surroundings provide a background for a discussion of the movement towards a new epistemic machinery in knowledge-intensive companies. The buildings that accommodate the companies in my study did not distinguish themselves from the surrounding buildings. This suggests that knowledge-intensive work has become everyday, trivial. Another issue explored in the paper is the welcome areas of knowledge-intensive organizations, where security as well as impression management are performed as technological and symbolic machinery.

The three companies in the study organized their business premises quite differently. Arguably, the way that they chose to organize their locations physically is an indication of the way they think about the organization of work. For example, widespread cubicle design could foster an individualistic and discipline-based work environment. However, we cannot say that such physical machinery will always produce either collaboration or more individualistic work styles. The way this machinery is used and framed is an important part of the larger epistemic machinery of the company.

The paper ‘Dressing for Credibility?’ explores the credibility ascribed to clothes as front- and backstage machinery. The discussion evolves around the myriad ways knowledge workers deal with credibility through wardrobe, and the machinery of front- and backstage in relation to attire. Clothes were used as symbolical markers, as individualistic images, and to relate to various groups. Some of these mechanisms are less well communicated, but all form a part of the epistemic machinery, above all by facilitating communication within and between relevant groups of actors through the management of symbolic similarity and ‘proper’ dissimilarity. Knowledge workers dress to convey membership, backstage through similarity and front stage through being suitably different from clients and audiences.

In the paper ‘Configuring Designers?’, the focus is on the DSDM method as machinery. The Dynamic Systems Development Method (DSDM) is a procedure that is supposed to facilitate user participation and make it a more efficient element in the design of computer systems. To perform as intended, the DSDM method needed technological, expert and social machineries to be operated. It was not possible to use the project control method without extensive guidance and management. The presence of various supportive machineries was critical to the use or non-use of the method. The DSDM method may be interpreted as a machinery that offers tools to create and shape an arena for user participation. In spite of the opportunity for participation, interaction is regulated by the methodologies and economic constraints of the project. In the end, a strong user involvement was too costly, but it was also rendered difficult through design methodologies that lacked proper conceptualisation of non-technological issues. On one level, we observed a complex interaction where software engineers and users configured the system design process as well as each other. However, the DSDM machinery only allows for technological communication, and as a consequence, the technological machinery was the hegemonic basis of interaction.

The paper ‘Testing Computer Systems: Code, Customers, or Contracts?’ is concerned with the different phases of testing a computer information system under development. In the analysis, we saw how various testing machineries were used, but also how they may conflict or be dysfunctional. A striking example of the latter is the communication practice between users and system engineers, where both parties found it difficult to convey information and knowledge and thus validate the outcome of the design efforts. This problem seemed to be rooted in the epistemic culture of the company and the strong belief among software engineers in their ability to master technology as well as to model the knowledge of future users. A surprising finding was how, in the final instance, the juridical contract was invoked to decide on the workability of the system. Here, we see a kind of commercial-legal machinery interacting with and imposing criteria upon the larger epistemic machinery of software design and testing.

Throughout the four papers presented here, just a few elements of the larger epistemic machinery are discussed. The goal has been to extend the understanding of what elements should be included in this concept, to make it possible to use it as a framing element. The ambition has been to add elements to the concept of an epistemic culture and extend its usability and substance. To further understand the epistemic machineries, the focus will be on other forms of devices, including materiality, and representation of objects as entities.

Materiality, objects, and practice

Law (2004) defines materiality to be about the material, where the material is treated as a continuously enacted relational effect. Law goes on to say that the implications are that materials does not exist in and of themselves. Materials are indefinitely generated and can be potentially reshaped. It is vital to distinguish between materiality and materialism. Materialism is the antonym of idealism, and puts forward that what is real is material, deriving the ideal from material arrangements. On the other hand, from the concept of materiality there will be made no *a priori* difference between the material and the ideal (Law 2004:161). However, materiality affects work organization and the way we think about possible ways of organizing.

Further, Law emphasizes how the mode of ordering, so central to the work of organizing, is always limited. An organization consists of a wide range of heterogeneous materials: people, devices, texts, decisions, organizations, and inter-organizational relations. Law wants to tell stories about these materials in order to convey an understanding of the social world as materially heterogeneous. It is important to also consider 'non-social' materials such as machines, animals, and architecture. Law urges a relational materialism that takes into consideration non-social materials as well (Law 1994:24).

According to Law, all materials should be included in the analysis, and they should be treated as products or effects rather than as given properties. Still, the analysis will be quite complex, and perhaps it is not manageable or possible to include all dimensions. In my dissertation I chose to select a few dimensions when studying the work organization of the companies that I investigated. I singled out a method for user participation, the DSDM method, as one material object from which to study interaction between users and software engineers in a computer system development project. In addition, in the paper focusing on testing, the testing procedures displayed a range of material aspects that influenced the project work, like database technologies, communication procedures, and contracts.

Nevertheless, what is the material? Is it all about relational structures? Fujimura (2000) argues that culture is not an autonomous entity, separated from materiality. Rather, materialities have the ability to change culture, but at the same time, culture may also change materialities. Fujimura's use of the concept of culture refers to a specific practice located in space and time. Relying on her experience, she argues that it is possible to study the assignment, assertion, or denial of cultural categories as part of the production of social and cultural order and conflict. People and practices in an area would shape imaginaries, meanings, and different understandings.

On the other hand, Law stresses that practice is messy, an insight garnered from doing knowledge practice ethnography. Knowledge is often produced in ragged ways in research, he observes. Through an ethnomethodological approach, it is possible to go behind the official accounts of how knowledge is produced (Law 2004:19). Practices may include architecture, texts, instruments and so forth, including the work and effort of scientists or other knowledge workers. Latour and Woolgar (1986) found that scientific knowledge was produced in a more or less messy set of practical and material contingencies. In addition, practical science produces as well as describes its realities. Scientists or knowledge workers more generally constitute diverse tribes with their own cultures, beliefs, and practices, where they produce knowledge and accounts of reality (Fujimura 2000, Traweek 1988, Knorr-Cetina 1999, Latour and Woolgar 1986).

Practice will be local, but must be understood in a larger context. Therefore it is necessary to analyze culture and science in terms of localized practices; for example, by analyzing small work cultures to investigate their particular features. However, it is important to not only look at particularities. Fujimura emphasizes that scientific practices are dependent on knowledge flows, protocols, people, and materials that need to be adapted to particular local situations. On the other hand, it must be possible to codify the produced knowledge outside of the local context to make it accepted as a valuable resource. Therefore, my approach has been to study local practices, but I do think that local practices have a basis in the larger context. I have had a special focus on the various tasks the knowledge workers execute and the various material statements or objects at the work place. The latter includes design and use of office space.

The focus on objects in laboratory studies is not exceptional. Knorr-Cetina (1999), Latour and Woolgar (1986), and Traweek (1988) included objects in their analysis. Traweek interpreted the detectors as symbolic expressions of the epistemic style of high-energy physicists. To the physicists, the detectors were the material evidence of the research community's vision about the production of new knowledge in particle physics. Latour and Woolgar, on the other hand, offer an exact description of the laboratory's exterior and interior design, such as an overview map and photographs of how the researchers worked. The broad reference frame was the mythology surrounding the laboratory work, and within this frame of reference it was possible to see some of the actions and work experiences of this special culture. Latour & Woolgar (1986:64) maintain that the construction of a phenomenon does not depend upon a specific material condition, but will be constituted by the material setting of the laboratory. This has been an important insight to my study of project work and what goes on in a knowledge-intensive work environment. The material structures, including dress codes and office design, also constitute the material setting of the work. How can these material objects contribute to a wider understanding of knowledge-intensive organizations?

Knorr-Cetina (1999) emphasizes that there are various objects involved in knowledge production. In her study, these are a part of the laboratory context together with the researchers and their efforts. Objects may be seen as centralized and integrated devices of expert regimes that exceed an individual expert's lifetime. Thus, they help stabilize collective conventions and moral orders that the researchers were devoted to and a part of (Knorr-Cetina 1997:9). It is therefore necesarry to have an understanding of object relations. These are not simply positive, but perhaps more dynamic and ambivalent, but it is nevertheless important to remember that people often have long-standing relations with objects (Knorr-Cetina 1997:12). Such knowledge objects are more fluid, open, question generating, and therefore complex.

Knorr-Cetina highlights that there are many kinds of objects, not only those that experts define as important. The object relations would be constitutive of relations more generally, since an expanded notion of society also includes material objects. Material objects can assist in the creation and conceptualization of locality. Through the objects, it is possible to externalize human relations because we live in a collective with the objects (Latour 1999a). The materiality of science in an experimental and instrumental set-up will then be understood as the process of producing special kinds of relations, and turning these into traces. Realities are made; they are effects of the apparatus of production in Latour and Woolgar's (1986) view.

Knowledge objects are the material things and relations in the organization. In a way, they are those material things and relations that are used to produce knowledge. My goal has been to extend the understanding of what these objects are.

Different spaces for materiality of knowledge work were addressed in the paper 'The architecture of new knowledge factories'.

Although it is not a good idea to become a space and place determinist, it was apparent that the architectural design had implications or provided affordances for the performance of work and collaboration. However, the architectural design of the studied knowledge-intensive companies was more ambiguous than I had expected, working from an assumption that there would be a kind of Mode 2 architecture. The modern business buildings had restricted access, and those with access were clients or in some other economic relationship with the companies. As mentioned previously, the buildings were characterized by rather mundane expressions. These knowledge-intensive organizations did not need a symbol-saturated architectural design to communicate authority and importance to society.

An object of materiality related to all kind of knowledge workers, but seldom addressed, is the theme of the paper 'Dressing for Credibility'. How people dress is the most visible feature presented to the outside world, but without a clearly articulated focus in many companies. Within the knowledge-intensive companies, the products they sell can be a bit blurry to customers. Therefore, the credibility issue related to the sellers and eventually the producers of the knowledge is important as an object. The focus on front- or backstage work settings became important to the creation of tales about dress. If the knowledge workers were acting on a defined frontstage, the engagement in power dressing was more apparent, preferably with subtle modifications.

In the two papers 'Testing Computer Systems: Code, Customers, or Contracts?' and 'Configuring Designers', we observe how software engineers, in the case of the companies ITcom and Calculus, tried to stabilize the understanding of the technical products they made for their customers. Their products were knowledge objects, and these objects are both visible and not- so visible. Rather, the objects were ideas, which are ascribed meaning. To the progress of a project it was important that the objects (the software system under development and the project management tools) were given a stable value and meaning.

Many of the strategies software engineers used were done to try to stabilize the understanding of the object to the outside world (users and clients), with the help of project control systems and their interpretations of the contractual terms that provided the project's legal framework. In addition, users and software engineers did not talk about the same object because they understood the objects differently. For example, users and software engineers ascribed different meaning to the software under development, and they had different expectations of the system.

Representations in and of the production of knowledge

Latour (1986) laments that in our dichotomization of society, we are unable to provide useful explanations. How are we supposed to study society then? In Latour's opinion, it is important to keep the various effects in place while seeking explanations more mundane than the great dichotomies (Latour 1986:3). What is then mundane? Latour answers by saying that it is not the explanations, which see science as a superstructure. The goal is rather to look for more 'parsimonious' accounts, heavily empirical, but accounts that are capable to explain the effects of science and technology. Therefore:

> It seems to me that the most powerful explanations, that is, those that generate the most out of the least, are the ones that take writing and imaging craftsmanship into account. They are both material and mundane, since they are so practical, so modest, so pervasive, so close to the hands and the eyes that escape attention. (Latour 1986:3)

The method is then clear: the way is to go deep and mould into the environment under study. However, what are parsimonious accounts? Perhaps representations are the practical, modest, material and mundane explanations. What are representations then? They are the devices used in science or other knowledge productions to resemble the object analyzed or manipulated (Lynch and Woolgar 1990). Lynch and Woolgar's starting point is that in science there are many types of representational devices, including text, graphs and pictures. Their key finding is the heterogeneity of representational order. A representation will contain more than the diverse devices applied because it also includes various theoretical principles and functions. Examples of the latter are resemblance, symbolic reference, similitude, abstraction, exemplification, and expressions (Lynch and Woolgar 1990:2).

Lynch and Woolgar observe that a main science studies approach to investigating technical content was to follow scientists' work more closely, using ethnomethodological approaches. Many of these efforts have already been discussed (Latour and Woolgar 1986, Knorr-Cetina 1981, Collins 1985). Latour and Woolgar (1986) argue that the extract of scientists' work in laboratories is papers or texts, which they term inscriptions. Thus, the texts produced in science are not 'natural objects', independent of cultural processes in the research community. Rather, the texts are extracts from the scientific 'tissue culture', where the findings are presented in different ways to order, shape, and filter the samples and turn them into understandable graphic matrices for their research community.

> Hence, to analyze representation is to expose the conjurer's tricks through which chains and networks of similitude are laboriously built-up and then 'forgotten' in the presumptive adequacy of their reference to an 'original' (Lynch and Woolgar 1990:7).

Accordingly, this is the way to reveal the complexities of the representations used in science or other places producing knowledge. The method requires a presence at the production facility under study. Representations are not about finished products, but rather about the process towards the product's production. Therefore, it has been important in my study to mould into project settings and observe the production of the various objects.

Objects and representations are interconnected. The point is that it is only possible to know objects through representations, although Lynch and Woolgar maintain that it is important to be reflexive when studying representational practices. The need for examining the background or the heterogeneous social context for the use and composing of representations was also underscored. Another point was that when displaying other representations, we also use and make various representations. A core point from this research is that representations are important for holding networks together. In particular, scientific representations are products of multiple translations of form and meaning. Across the network, these translations will go back and forth between the observer, the observed, and the means of observation (Jasanoff 2004:23).

How are we supposed to act to get information about representations of knowledge production? Latour (1986) contends that the argument used in a process of producing a credible fact has to be convincing. This has to occur throughout the description of the analysis. The reader becomes convinced of the argument by the moves done in the analysis, where '*you have to invent objects which have the properties of being **mobile** but also **immutable**, **presentable**, **readable** and **combinable** with one another*' (Latour 1986:7). Therefore, the analysis needs to be open and expounded for the audience.

Inscriptions are images or texts that have been treated in the laboratory and appear as extracts, wherein the content has been cleaned, redrawn, and displayed as figures supporting a text (Latour and Woolgar 1986, Latour 1986, 1987). For example, the most powerful tool to display findings is visual figures that argue for their validity (Latour 1987:67). However, a consequence is that when something becomes visible, other things become invisible. An important factor during the construction phase is that the previous phase will become less visible. The new phase hides the previous when it disappears from sight, and each part hides the other, as they become darker and darker black boxes (Latour 1987:253). Therefore, those who maintain the official record of the construction phase will be in a position to represent the history of the construction. This does not imply that this story is the 'true' story, but rather that this representation will be the authorized story. This form of representational power was a visible characteristic in the paper about testing during software development. The interpretations of the reports from end-users meetings done by the software engineers, as well as the change reports and the contract where the official accounts of the development phase will fall into this category because they, mostly, had written the different representations. There will also be many 'black boxes' in this account of the project, but those who draw the official account will have more definitional power.

When the client takes more control over the project, the representational story can be different. For example, in the paper 'Configuring Designers', one client took a firm role during the development phase. A smart move seemed to be to hire software engineers from another company to represent them, overseeing the process and acting as a kind of knowledge broker. In particular, these 'client experts' acted as translators and communication links with respect to the user representatives' depiction of their work process.

In the same project, management used visual representations of the project as coordination and control tools. The most important example was a milestone schedule graphically represented at the project facility, covering a wall in the main corridor. The poster was a reminder of the time limits of the project, but it also created a meeting point for all the different user representatives. Moreover, it was a visual representation of an underlying understanding of projects as coordinated efforts, with a start and an end, and therefore expected to have linear progress.

Thus, such visual expressions and representations are not innocent. Henderson (1995) studied the way engineers relate to the different visual representations of what they do. In this manner, they create a visual culture, which in turn constricts and constructs the literal ability to see or imagine their situated practice. Henderson's claim is that the visual culture, which the engineers are a part of, structures their work. It also imposes criteria of being an insider allowed to participate in 'real' discussions, as well as constructing outsiders, lacking in expertise. The 'Configuring Designers'-paper provides similar observations, above all through the slightly ironic strategy of the client hiring additional software engineers to facilitate 'real' participation in the project.

According to Henderson, visual representations function as boundary objects (Star and Griesmer 1989), in addition to being conscription devices. Boundary objects is an analytical notion, which allows different group members to cooperate by making sufficiently flexible and robust working objects in the localized context to achieve a stable identity across different sites (op.cit.). Boundary objects may be used for translation and communication. They may be both abstract and concrete, given meaning according to the setting.

Conscription devices are devices that have a communication function in a project, but include some power issues in the relationship. Conscription devices are a subgroup of inscription devices (Henderson 1995:214). Both are very powerful tools, especially in relation to users or clients in a project context. A rather obvious conclusion is that different people read embedded codes differently, especially when coming from different work and professional contexts. However, this was something about which the software engineers in my study were not really conscious.

In my papers about project control systems (DSDM) and testing, the ironic point is that the software engineers made systems for users based on simplified or extracted interpretations or inscriptions and representations of the users' everyday work. The extracted versions were used to specify the work tasks delineated in the new program. In such knowledge support systems for routine based activities, there is little room for extraordinary cases. The simplified model used in such programs does not fully support solving more complex cases.

Through contracts and project control systems, the software companies I studied tried to impose a high level of predictability on their work. Since software engineering involves many time-consuming and uncertain elements, this seems rational. However, as observed from my papers, the representations made of software work through the contracts and control systems produced contradictory views. On the one hand, all companies emphasized the importance of interactivity as well as iterations. Nevertheless, their management tools were built on linear, waterfall representations of project work, and these depictions of the development process gained ground because they failed to implement an iterative frame around the process. There is no such thing as iterative contracts, and the project management tools do not cater well to iterative work either. Thus, despite new and more advanced software development philosophies, the underlying linearity of the project work representations found in the control tools seem to create a strong drift towards linearity in project practice as well.

In the dramaturgical sociology of Goffman (1959), there is a difference between the presentations of self and self as a hidden reality lying behind and producing those representations. On the other hand, Latour (1999b) highlighted how we are dealing with the staging of a given design, where only one set of dramatized inscriptions or texts is focused on. However, in his study of Pasteur, Latour showed that there are many aspects involved in how objects are represented. Here, Latour demonstrates that Pasteur worked on the research stage as well as on the scene, with a plot. Pasteur was a master of fostering interest groups and persuading members of the interest groups to share his opinions while he conducted the actual research. This fusion of interest became a factor because Pasteur was able to set the stage and scene (Latour 1999b). It is important to broaden these perspectives and redefine and open the way we see knowledge and knowledge production, where the visual parts of knowledge representation seldom have been much attention.

How we interpret the way people appear is not separate from other parts of society. How we choose to dress in a professional setting is related to various considerations. In the paper ‘Dressing for credibility’, I discussed various approaches to dressing in knowledge-intensive companies. How people dress in a business context is related to business, professional identity, personal style, and clothing norms. I emphasized approaches to dress codes taken and expressed in the five different companies in the study. The different approaches were divided into two categories, although these categories were not exhaustive. The results were that dress codes in the companies were related to front- and back stage performance of work, where this was related to the visual performance. How we dress and comprehend dress codes is part of the material representation of knowledge. The material experiences of dress codes contribute to how they translate front- and back stage activity. Dress codes are part of a special explicit material to visual representation in and of knowledge production. The shared visual representations and the engineers’ ability to read encoded meanings from the representations can facilitate coordination and cooperation.

On the other hand, this may not always be the case. The dressing approach can be used as a dramaturgical point to possibly set the stage. Latour (1987) suggests that rhetoric is important in how text is interpreted. One aspect of this is the use of modalities. A positive modality is an effort to lead a statement away from its conditions of production, thus making it more robust, increasing its credibility, and allowing the statement to have positive consequences (Latour 1987:23). Negative modalities are expressions that focus on how the statement has been produced and explain why it is weak or solid. Since clothes are statements to the world, they may work as modalities in Latour’s sense. Power dressing, for instance, might give the knowledge worker a professional appearance, and it could convey an aura of authority. However, to try to impose a positive modality could also be comprehended as a negative modality by the counter partners or clients. Dress codes may be read as representations of the knowledge production culture. Always using formal clothing appears as an expression of a belief that the production of knowledge is not robust, and that positive modalities are needed to support claims about knowledge. The informal code seems to express a more optimistic representation of the production of knowledge as naively credible. The hybrid version, in a sense, makes use of both representations. One dress up for public proofs, while disregarding formal clothing is allowed among peers.

Another ambiguous representation is the very materiality of building design. Buildings and architectural structures are important dimensions of the material aspects of new knowledge cultures, and it is reasonable to expect some functional relationship between a building and the activities that it accommodates. Buildings are products of human efforts, and it is necessary to take various consideration concerning technological, social and cultural options for use (Ryghaug 2003). How is it possible to analyze buildings as both fixed structures and objects that are used and to which meaning is ascribed? Lynch and Woolgar (1990:13) argue that objects and representations are interconnected, where objects can only be known through representations. Buildings can be seen as objects of (re)interpretation; they tell stories and form a representation when we deconstruct the buildings materially and semiotically, as Gieryn (2002) emphasizes. Potential use and the concealment of opportunities may also be a part of the social relations and practices performed in buildings. Like any other technical artefact, Gieryn argues, buildings are sites where people act, but at the same time become structured by the physical structures. Like Jasanoff (2004), we can say that knowledge-intensive work and the buildings where it takes place are co-produced - or rather, that *knowledge about* knowledge-intensive work and such buildings are co-produced.

To try to further understand office buildings as both a social structure and a material structure and keep some of the ambiguous representation of the building design, I will use Mol and Law's (1994) claim that the social does not exist as a single spatial type. Rather, it performs several kinds of spaces in which different 'operations' take place (Mol and Law 1994:643). The authors emphasize that space can also behave like a fluid, which is why they use the term 'liquid architecture'. However, the important point is that spaces are not fixed but can be interpreted and viewed differently according to context.

The question then is how we should perceive space. A possible solution is to see space as an allegorical representation. According to Law

(2004), a representation will be an allegory when denying its character as allegory. Law defined an allegory as something other and more than explicitly expressed. Perhaps we could say that it is an extended symbolic representation. To interpret an allegorical representation, it will be necessary to decode meaning and read between the lines, both in regard to the use and understanding of the material structure of the building.

Using an allegory, it is possible to make room for ambivalence and ambiguity in the understanding of the reality, because manifests about realities do not need to fit together. In Law's (2004:93) opinion, architecture is a good source for an allegorical approach. To grasp every angle with built form can be difficult; for example, starting with the construction and continuing to how the building relates to the society at large and how users utilize the building. This is especially the case if the goal is to tell a single story of interpretation and use of building form. To treat architectural expressions allegorically is a possibility, because one can include things that are not directly related to the material structure.

The allegorical representation of the design can therefore be flexible and include ambiguous and ambivalent explanations and experiences. In the article 'New Architecture of Knowledge Factories: A Mode 2 design?', the question raised was how we build for 'the new production of knowledge' and how we represent knowledge-intensive work materially through workplace design and architecture. In the paper, I tried to read the architecture of the knowledge-intensive companies from the features depicted through the Mode 2 understanding of knowledge work as described by Gibbons et al (1993) and Nowotny et al. (2001).

Mode 2 is characterized by flexibility, teamwork, network, and cooperation. My concern was whether these changes would be materialized and represented through the design at the work premises studied. My finding was that the architectural design was more ambiguous and diverse than expected from the Mode 2 theory. With an understanding of built design as allegorical representations where the understanding of the built form is not fixed but flexible, the interpretation of the surroundings as an ambivalent explanation is allowed. A building is more or less materially fixed, but the use and interpretation possibilities are not fixed. The companies organized their offices in diverse and shifting ways.

The aim of this dissertation was to analyze the culture of knowledge-intensive work, particularly the under-communicated material aspects. I have tried to show how material features like clothes and architecture, as well as contracts and project management tools, are important parts of what Knorr-Cetina (1999) calls epistemic machineries. My main theoretical inspiration has been science studies, which I have drawn upon to study knowledge work outside what is normally considered to be scientific institutions. However, the science studies concepts and approaches also contribute importantly to the understanding of the production of knowledge in such contexts. For example, the concept of epistemic machinery provides interesting insights into the diversity of ways of producing knowledge in professional service companies by highlighting the importance of the assemblage of methods, practices, interests, relations, and objects in the performance of this sort of work.

In this paper I have particularly focused on the impact of representations of knowledge-intensive work upon the performance of such work. Dress codes are constructed to provide both similarity and dissimilarity with clients and audiences, thus making the performance of similarity and dissimilarity inherent in this sort of work. Architecture of knowledge-intensive workplaces represents an understanding of such practices as mundane and trivial, but also exclusive and secretive in a way that gives clients some prerogatives regarding the use of knowledge products. The physical shape of the office space reflects local thinking about teamwork, but the outcome is in accordance with respect to the actual doing of teamwork. We have also seen how contracts and project management tools are made from linear representations of knowledge-intensive work, thus imposing linearity as the hidden expectation about how such work should be performed.

These observations, I believe, add importantly to previous science studies investigations into scientific representations as devices to provide resemblances of the object of inquiry, particularly as ways of narrating the content of the knowledge produced. I have shown that knowledge-intensive work also produces representations of itself, and that these representations shape knowledge-intensive practices. This indicates the importance of concern for the dual nature of representations, as communication but also as shaping features.

An approach to method through thick and thin

I have chosen to call my method a modified ethnographical approach (see also Smith 2001). To label my investigation as an ethnography is not fully accurate from a strict anthropological understanding. Therefore, the prefix ‘modified’ has been added. What I have done can also be described as participant observation with interviews, meaning that I have actively observed and interviewed at three different case organizations through thick and thin.

I will discuss ethnography here because this approach gives an introduction to why it is important to get a thorough understanding of the ‘culture’ one invades as a field researcher. Further, my motivation for and interest in ethnography is that sociological writing about participant observation is often a bit unclear about what one does when conducting observations. The ethnographic approach is much clearer about the goal of the research and the actual method in the field. Traweek (1992), especially, emphasizes that to do fieldwork is to observe and listen while the researcher participates and talks. To write ethnography is to represent a culture, or various selections of the culture (Van Maanen 1988:1). The ethnography ties together fieldwork and culture. It is a serious matter to represent a culture through an ethnographical approach, especially since the written description of others is not a neutral affair. Van Maanen (1988) points out that fieldwork is the best way to gain knowledge about others, since fieldwork means to live with and live like those we study. The concern is the meaning of actions and events from the field (Heyl 2001), and this has been my focus in the field.

In addition, Traweek (1992) emphasizes that fieldwork and participant observation does not have the same meaning for anthropologists and sociologists. In a sociological sense then, I think, I have done what is required of a participant observation and a case study method.[2] My goal was to be able to make a thick description of the cases and the phenomena under study (Geertz 1973), in order to be able to do a detailed qualitative analysis. In addition, I have followed up the fieldwork with interviews of relevant project members.

Heyl (2001) identifies interviews as ethnographic when the researcher establishes respectful on-going relationships with the group members, where it is important to use enough time and have openness to discuss the matters of interest during the interview. When researchers more or less invade other people by doing interviews like this, it is important to think through the role that the researcher takes in the interview and the construction of meaning during the interview process. Therefore, I think it is important to let the interviewees get the chance to talk as much as they feel like doing. However, one should carefully direct them to the different topics that are important for the study. It is also central to quote informants when writing up the study. In my four articles, I have tried to give voice to

[2] Van Maanen (1988) writes that the niche in sociology for ethnographic fieldwork is narrow. The first ethnographical method came from the University of Chicago, and the spread of the method has been sporadic and uneven. It has never achieved the status that it has in anthropology. This is perhaps the reason why I am very conscious about calling my form of ethnography an approach or rather a case study.

my informants, with the limitation that quotes have been translated from Norwegian and cleaned for surplus words.

The technique of writing articles invites you to be concise, brief, and make to- the- point statements. This does not always match well with the ethnographical narrative tradition. This is not to say that it is impossible to write good articles with an ethnographical approach, but within the article genre, perhaps the writer will loose some of the thick description because available space is limited, although sometimes it can be a greater challenge to write in a manner that is more to the point. Van Maanen (1988:23) criticizes sociologists that write ethnography for having too little interpretive nerve and writing things that are restricted in range and full of jargon and facts, so that one can satisfy some fetish of documentation or legitimacy. Therefore, it is important to write with an open mind and to remember to let the story of the field unfold.

In the field of science studies, it has been highlighted that a robust case study is not only descriptive. It is also essential to identify important case features and the context related to the case. The social shaping of technology (SST) is a pluralistic approach, where a rather mixed set of models and concepts are used to unfold research contexts (Russell and Williams 2002). A method to prevent a too- restricted representation of the field has been to expose my writing to different audiences, both nationally and internationally, and listen very carefully to their comments about the articles at various stages.

My motivation to use the fieldwork method was that it is a good approach when you want to understand what people actually *do,* not just get a description of what they think they do in, for example, an interview. In addition, a goal was to lay open the culture under study through thick descriptions and to decode the levels of meaning within (Knorr-Cetina and Merz 1997). It is necessary to be in the field for some time to uncover differences within the culture, and this was also my experience, although Emerson et al. (2001) contend that the researcher will construct the field in accordance with the research goals and the negotiations with the hosts and informants to get access. Later, I will go further into the discussion about accessibility and adaptations.

Within science studies, especially laboratory studies, it has been important to follow science work closely. Callon (1986) is engaged in how nature and society are woven together, and he underlines three principles for method assemblage. The first principle was not to judge the actors; the second is to use the same measuring instrument on both the technological and social aspects. The last principle is to follow the various actors and try to understand their way of defining the world, regardless of who the actors were (exemplified by 'following' the scallops). The goal is to get a better understanding of society and the various actors, which includes accounting for how the actors define their identities, their action space, and available options.

From the start of my dissertation project, I had a 'thing' about culture, because the notion captures many dimensions of society. However, it is nearly an impossible notion to use because it captures a process or time element and also refers to a particular class of things such as shared knowledge. At first, I tried to consider the shared, informed, embedded, and shaped, routines in the society under study, which are among the things one tries to uncover through cultural analysis and observation. An important point of a cultural study is that the culture can be experienced only as the actions and words of the members in the social group, and the fieldworker has to interpret the impression he or she reveals from the field. Van Maanen (1988:3) argues that culture is not a visible phenomenon as such, but is made visible through its representation.

My goal with the fieldwork approach was to get a thorough understanding of the social groups I was going to study, as well as to experience their everyday work environment. The anthropological understanding of fieldwork and ethnography emphasizes that the researcher needs to stay a lengthy time in the field, interacting closely with people on their home ground (Fangen 2004). However, it is a question of how long time one needs to stay to get a good understanding. According to Van Maanen, we could call the method participant observation, although the notion is double-edged because it is too precise and too visual. It is important that the fieldworker leaves her normal environment and feels a physical displacement. During the fieldwork, the researcher can share the investigated environment, problems, background, language, rituals, and social relations (Van Maanen 1988).

The fieldwork is only the means to an end, and the ethnography is a means of representation. Through the ethnographical representation, the fieldworker translates meaning from one setting to a new one. Traweek's (1988) approach was to give a representation of everyday life in the field, including accessibility, impressions, and diversified understandings. Law (2004), on the other hand, emphasizes that it is not possible to get a whole and thorough picture of everyday life. Further, from an ethnographic approach, the outcome would be to assemble a condensate of traces in the field. There are so many different actions going on at the same time. Therefore, it will not be possible to get a full picture of every action.

Law is also an advocate for new innovative methods that allows us to see multiple realities. There will be no general methodological rules when there is no general world. Therefore, there has to be a particularity in the understanding, which undermines the universal and general. Instead, we need an understanding of realities as specific and enacted. Further, Law claims that when the universal disappears, then the local will also disappear. The result is situated enactment and partial connection (Law 2004:155).

The better the fieldworker tries to describe and illuminate the field experience, the better an impression the reader can get of how the fieldworker has interpreted the situations. Traweek (1995) claims that she focused her attention on keeping the light on (metaphorically speaking) when accounting from her research. During her narrative writing, she tried to share her view on how she reached her understanding of her fieldwork.

Law wants us to pursue a 'modest sociology' which:

> is one which tries to occupy the precarious place where time has not been turned into cause or reduction, and where relations have not been frozen into the snapshot of synchronicity (Law 1994:13).

How is it possible to do modest sociology? Law's first answer is that we should tell stories, ethnographies, histories, so that it adds up to a thick description of the world. These stories should not pretend to give all the answers but suggest that there are some effects that are generated. Second, one needs to talk about patterns, regularities, reproduction, and so forth, but it is important not to be dogmatic about these patterns. It is perhaps possible to think of this as a dogma film approach, where the occurrences are shown but not brushed up and 'made-up' by the film camera (method) and director (researcher). The third component in the modest sociology is the claim that the social is better seen as a recursive process, rather than a thing.

To sum up, the case study based on participant observation would be a good approach to study representations of knowledge, knowledge work and knowledge workers. In the next section, I will describe in greater detail the choices made during my study.

Why and how?

To gather field data is a messy process; it is unruly, conflict ridden, and always problematic. The writing process is also messy because a huge amount of data needs to be written and rewritten: to write it out, categorize it, and in a way discipline the data. What we write grows out and is effect of a context, but it can also conceal the context, as Law observes (1994).

It was a rainy and stormy day on the east cost of Norway. This could have been a nice sentence to introduce the methodological report of my doctoral thesis, but such a story-telling sentence does not capture the methodological confessional conventions and limitations. As Traweek (1992) states, these conventions are powerful in the research community. However, was that the story, and what kind of story would I tell from my project? There have been many rainy days, but there have also been many sunny days. Actually, most days are normal, white-greyish. In any case, I have learned that a linear story is not always the correct account since the development of a project is rather an alternation of variation and selection (Pinch & Bijker 1987). However, I think that in this introduction a linear approach would be useful to provide an informative account of my intentions for this project.

At a master course in the sociology of organization, I learned that to study culture in organizations was a very 1980s phenomenon, and that the concept of culture was a dead end in sociology. Despite this, I wrote a master thesis about culture in consulting firms, using a more anthropological understanding of the notion together with insights from science and technology studies (Hope 1999). When the opportunity to apply for the KUNNE 2[3] scholarships came up, I developed a project proposal with a starting point in the master thesis, but with a wider focus that more precisely related to what I have called knowledge cultures. In the first outline, the centre of attention was how knowledge was used and organized in knowledge-intensive organizations. More specifically, I proposed to study how knowledge cultures materialized in the context of project work in such companies.

The stakeholders in the larger KUNNE 2 project included software companies, consulting engineering firms, communication agencies, and applied research institutes. I chose to contact three of the KUNNE 2 stakeholder companies, and they agreed to be part of my project. Representatives from the companies proved to be open and positive toward participating in my project, particularly since the project was part of the KUNNE 2 portfolio.

The participating companies and informants have been given fictive names to make them anonymous, because it is easier for me as a researcher to express my understandings from the field experience when I am not tied to a given understanding of the companies from the outside world. Another motivation is to protect the informants, so that the informants can speak freely without thinking of possible reactions

[3] KUNNE is a project coordinated by Sintef Industrial Management, Department of Knowledge and Strategy. It is a network of actors concerned with understanding how knowledge is created, managed, developed, and used. The partners in KUNNE 2 came from private and public organisations, universities, research institutes, branch-, and governmental institutions. See: www.kunne.no

afterwards. Things said in one context could, for example, be understood very differently in another.

The three case companies may briefly be described in the following manner:

Calculus

The first thing I noticed when starting my field work at Calculus in the autumn of 2000 was their special focus on processes, and their special understanding and use of the notion of knowledge. The company was presented to me as a technologically focused knowledge-intensive firm, where the majority of the employees had a major degree from university or college. Most of them held a masters degree in engineering, with a professional identity as ICT or software specialists.

A handful of well-educated software engineers established the company during the mid-1980s, after leaving a large technological firm. It was a spin-off, which the mother company supported, and they have continued to support the relationship by being one of Calculus' most important clients. Calculus says that their core expertise is knowledge management systems, knowledge technology, and information technology. Their products are mainly custom-made information and knowledge support systems for routine- based activities in organizations in the private and public sectors.

Calculus remained a small company during its first 10 years, but with a faster growth rate during the last decade. From being a company of 30 employees, it reached a peak of around 170 employees in 2001. After a turbulent period between 2002 and 2004, their staff is around 100 people today (2005). In a Norwegian context, Calculus is still a medium-sized company.

During the fieldwork, Calculus was described as process organized, with projects as the main unit of activity. This organizing model classified the different projects by their content. There were five different project divisions, and every division had a manager who was the head of that particular project portfolio.

As part of my fieldwork, I followed a large project which I have called NEST. The aim was to make a working process support system for a public institution. The client, who had ordered the system, was a hierarchical and bureaucratic organization with many decision levels, laws, and regulations to follow when handling their complex application procedures. During my participant observation periods, I had the opportunity to follow the project, and my goal was to understand the meaning workers ascribed to their everyday activities. I especially followed the project's work from within the design teams, participating in internal meetings, client meetings and testing. Initially, I wanted to see how technology planning, the choice of technology, user relationships, and collaboration among the users and project members might influence the knowledge culture of the project. It was a complex field experience trying to keep up with the ten engineers working with NEST, but my interviews with them helped my understanding of the situation.

I conducted the interviews mostly on a one- to- one basis. The interviews came late in the observation process, after I had acquired an impression of the project and could ask questions related to my experiences in the field. The focus during the observation periods at Calculus was to fill my notepad with details from the work surroundings, notes from meetings, discussions, and everything else I was able to describe. All together, I had contact with the project for a year and a half, with the first six months as the core phase. During the first six months, I spent five weeks at the company.

To broaden my impression of Calculus, I had the opportunity to compare NEST with two other projects, dissertation called COSMO and Par. A colleague, Eva Amdahl, conducted an investigation of the COSMO project some time after my initial study was finished, and she gave me the opportunity to participate in some interviews related to COSMO, including a group interview with people working on the Par project.

COSMO was also a computer system development project for a public institution. Par was another type of project, where the goal was to develop a software system. In all, we conducted five interviews or group interviews together, and participated in each other's different project areas, including meetings with Calculus' employees and users. This collaboration has given us an interesting view of each others' project and made the investigations more transparent. Therefore, one of my articles is written in collaboration with Eva Amdahl, in which we compare and contrast our two projects.

An overview of the number of informants from Calculus and how they relate to the different projects is given in Table 1. A more detailed account may be found in appendix 5.

Table 1. Informants from Calculus.

Project:	Total no. of project participants:	Total no. of interviews:
NEST	14	10
NEST Client	4	3
Others from Calculus	5	5
Par project	Group interview	4
COSMO project	Group interview	3

ITcom

ITcom is a large supplier of information and technology services in Norway. ITcom's focus is to supply consultancy services, design, management, and administration of business systems related to the IT sector. The company is also a large supplier in the Nordic market. It's web pages indicated that it uses metaphor architect to describe itself as a leading builder of the information society. ITcom emphasizes that it has solid industry experience across many business sectors. The company's website states that it will combine with this knowledge with its understanding and 'excellent knowledge of information and communication technology'. In 2002, when I conducted my field study, approximately 500 people in Norway were employed by ITcom. ITcom has its head office in Oslo, but also has branch offices in some of the larger cities in Norway.

I did my fieldwork at one of the branch offices where about 30 people were employed. On a day-to-day basis, about 15 to 20 people were present at the office, and some days there were even less. The rest were working at their clients' offices. Before my participant observation period, the branch office had experienced a setback the previous year, and about ten consultants and a secretary had to leave their jobs. Therefore, the office facility seemed a bit empty since they had not made any changes to the location or office structure.

The branch office supplied tailored IT systems for various customers locally, nationally and internationally. ITcom's main business areas are found in the energy sector, in the banking and financial sector, and in resource management services. Making E-learning systems had also been a core activity.

I had the opportunity to take part in the everyday work of what I have called the Ark project during a two-month observation period. Ark involved a team of eight people, and the aim was to develop an E-learning system for a Nordic client. During my stay at the Ark group, I followed the project work from within the development team, participating in internal, telephone and development meetings, testing, and informal meetings such as lunches. Every other day the project had state of affairs meetings, in which I also took part. Here, the project members told the project manager how their work progressed and whether there were any problems with the design. This was a way to control the development work and make sure that the goals were met at the various milestones.

Due to a very tight time schedule, the project manager did not allow any interviews during my stay. However, I followed the project closely and made extensive notes, communicated well with the project members and asked them during their working hours to clarify their everyday experiences. However, the project manager gave an interview, and I also managed to interview two managers at the head office. The core group of designers shared a project room, and I had the opportunity to observe the team here because I was assigned a small desk in the room. This was an excellent chance to experience the daily work and routines at the facility.

An overview of the number of informants from ITcom is given in Table 2. A more detailed account may be found in appendix 7.

Table 2. Informants from ITcom.

Project:	Total no. of project participants:	Total no. of interviews:
The Ark project	8	1
Others from ITcom	2	2

IFOS

The Research Concern is a research institution with quite a broad base of activities. I did fieldwork in one of its sections, which I have named IFOS. This institute combines competence in social science and engineering. IFOS' website states that its strength lies is in its ability to approach problems from a multidisciplinary perspective. The company wants to develop new knowledge and technology to increase customer's profitability.

IFOS have several departments. I have studied two of them, which I have named Department A and Department B. Department B has a branch office in another city, and to distinguish these two units, this branch office has been named Department B2. In IFOS, my main source of information has been interviews. They were mainly conducted during a two-year period starting in 2000, but the last interviews in Department B and B2 actually took place in autumn 2004. Most of these interviews were done together with my colleague Eva Amdahl. We used a semi-structured approach, with a focus on the development of the work place, their use of methods, issues of identity, and the performance of project work. During the latest interviews and visits at Departments B and B2, the main matter of interest was their architectural choices concerning their new office design. I did these interviews alone.

An overview of the number of informants from IFOS and how they relate to the different departments is given in Table 1. A more detailed account may be found in appendix 6.

Table 3. Informants from IFOS.

Department:	Total no. of informants:	Total no. of interviews:
Department A	5	5
Department A	6	Group interview
Department B	2	2
Department B	5	Group interview
Department B2	4	4

An account of everyday experiences

The next step was to get a better practical understanding of what participant observation involves. Therefore, I will discuss previous methodological accounts in relation to what I have done. However, I will first talk a bit about how I gained access to the case companies, because this was an important factor in carrying out the study.

Gaining access to Calculus and IFOS was quite easy. It was a bit more difficult at ITcom. The first time I talked to a representative of ITcom, at a KUNNE 2 meeting, the response was not negative but a bit hesitant. A few months afterwards, I contacted Marianne, the ITcom representative, and she directed me to another consultant in the firm since she was going on leave. I had a meeting with the new contact person a couple of months later, but I understood from that meeting that access could be difficult because the small branch office was not used to research involvement. Another factor was that the office had recently been through a tough period, with cost and staff reduction and therefore it was presumably reluctant to let a stranger in. Still, the contact person was going to try to get access and promised to get in contact with me soon.

Approximately a year after the first unsuccessful meeting at ITcom, I met one of the executives of the company at another KUNNE 2 meeting and was able to tell a bit about my project and that I had tried to get access. The manager was positive. He provided names to contact and made time for an interview. In addition, a middle manager at the head office was positive and helped with further access and interview. Then, I had the courage to try once more at the branch office, and contacted the first contact person (Marianne) again. After some e-mails, access was granted.

When I finally arrived at ITcom, the people on the project team were positive and willing to be a part of my research project. They asked many questions about my project and made sure that I understood how their routines unfolded through the day. Unfortunately, I became ill and had to end the observation period before intended. Therefore, my interview data is not as rich from ITcom as from the two other cases, but the field notes, the interviews with the managers, reports from meetings, and notes from talking to the project participants present quite extensive material.

As mentioned before, access to Calculus was easy and the people there were positive to researchers from the beginning. They had previous experience collaborating with researchers, and their participation with the KUNNE 2 project was well established at the management level. During the first encounter, the representative from Calculus was positive, and I got his e-mail address and contacted him some time after and was given access. During my first three day visit, I had meetings with the coordinator, Kim, and discussed my project while he told me about their company. Before my stay, Kim had arranged for three introductory interviews with engineers from different departments.

At the end of my first observation period, Kim promised to try to find a project that I could follow. Some weeks after I contacted Kim again, he passed on information about a project, including the project manager's name and e-mail address. Then, all I had to do was to contact the project manager, who responded quickly and positively to my request. Thereafter, I followed the NEST project on and off for a year and a half.

Access to IFOS was also relatively easy. A colleague and I organized separate group interviews for Departments A and B. These interviews gave us important insights into the two departments. Everyone at IFOS was very helpful and supportive of our project, perhaps because they were also researchers. The next step at IFOS was to conduct various interviews at the two departments, as well as with the head of the department. After the group interviews, we contacted individual researchers at IFOS directly.

Smith (2001) emphasizes that to do participant observation, interviews, and sustained observation in the field enables the researcher to get a unique snapshot of the field. It is possible to get a deep understanding of organizations and occupations. The fieldworker gets firsthand experience with the different voices in the field, the hesitations and silences, the interpreted meanings and the story behind their accounts of their daily experiences (Smith 2001:225). As Emerson et al. (2001:352) define participant observation:

> Participant observation - establishing a place in some natural setting on a relatively long-term basis in order to investigate, experience and represent the social life and social processes that occur in that setting – comprises one core activity in ethnographic fieldwork (Emerson et al. 2001:352).

Besides being in the field, it is important to get the inhabitants to speak to you develop a better understanding of the field. For example, the personal interviews that I conducted with nearly everyone I followed at the NEST project provided very good insight into the project. I would identify these interviews as having an ethnographic approach, in accordance with what Heyl (2001:369) declares as important in ethnographic interviews.

During the ongoing observation at the NEST project in Calculus, I established respectful (I hope), on-going relationships with the project group. They were supportive of taking part in individual interviews. During the interviews, I tried to use enough time and openness to discuss matters of interest. Afterwards, I handed back the transcripts from the interviews to the interviewees. They could comment on the interviews if they wanted.

The other interviews that I carried out at Calculus, IFOS, and ITcom mainly involved following the same interview guide and topics. The interviews lasted from 45 minutes to two hours and were conducted one-to-one in the informant’s office or in a meeting room. The interviews were taped and thereafter transcribed verbatim. The quotes utilized in the dissertation have been translated into English. When translating the quotes, I have tried to retain the informality of expression.

In IFOS and Calculus, group interviewing was a very fruitful method for gathering information and thoughts about the organizations. The group interviews were done with Eva Amdahl. They lasted for about two hours each, with an average of six participants. It can be very demanding to be in charge of a conversation with up to six participants, but we shared the responsibilities and managed to follow up different parts of the conversation from our semi-structured interview guide (Amdahl 2002).

The advantage of an interview is the ability to gather a lot of information and data quickly (Marshall and Rossman 1995). There is often a choice between depth and scope during group interviews because of the many participants. One is able to talk and get information about a wide variety of subjects but may miss a bit of the depth.

Emerson et al. (2001) also say that writing field notes is a core activity during participant observation. When in the field, one should try to write down everything that happened and, possibly, what did not happen, in addition to the more interesting parts and everyday accounts from the surroundings. My own field notes had a diary style to them, with descriptions from the work environment, the people, situations, meetings, and so forth. I wrote constantly during the day, but I must admit that the first days were often better accounted for than the last. The reason was that when entering the field every experience was new, and therefore more easily noticed.

Law (1994) also emphasizes staying in the field was tiring. He experienced that in the library at the facility he was studying, he could have some solitary space and relax from all the impressions. It was necessary to stay in the field for some chunk of time to get a good understanding, but I will argue that it was possible to understand the field from shorter stays as well, especially once I became accustomed to the field and was not entirely experiencing a new and unfamiliar culture. This is in conflict with mainstream anthropological understanding of time spent in the field (e.g. Van Maanen 1988, Traweek 1992), but it is a way to examine more cases. Nonetheless, breaks from the field and several shorter periods during the fieldwork is a much-used approach in sociology (Fangen 2004:99). Breaks could also enhance an analytical distance to the field and facilitate a critical view.

My experience was that fieldbreaks helped to get a new and fruitful perspective of the field when re-entering, and thereby I was able to write better field notes. Fangen (2004) argues that one of the advantages with shorter fieldwork is the possibility to work on the experiences from a few incidents. On the other hand, from a lengthy stay in the field there would be a vast amount of observations that could blur the picture. However, the drawback with shorter stays is the risk of not getting ‘the whole picture’ and losing important information. In any case, it would be unrealistic to achieve a completely full and accurate picture.

Field notes are a written representation that somewhat reduce the just-observed events, persons, and places, and allows them to be a part of the field experience. By reducing the complicated social world, these notes (re)constitute the world in preserved forms (Emerson et al. 2001). Field notes allow the researcher to review, study, and think about the experiences many times, although my experience was that there were many things I left out because I did not see them as relevant or did not notice them. Therefore, field notes are selective and constructed in the situation. I had my blue or green field book with me at every meeting or next to me during the day. Therefore, the engineers were used to my method of writing. They never protested. But they saw it and commented on it at various occasions, often in a jovial tone. The engineers expressed some curiosity regarding what I wrote, and I tried to explain the intentions behind it.

More about the study and the process

My study has been open, and those I have studied have known of me as a researcher interested in their working environment. It is another question if they really understood what I was gathering data about, but I always gave an introduction of my research to the project members before starting up at a new site. This presentation consisted of a short introduction of myself, my profession, the research goals, account of the methodological approach, and the reason why I choose to study their project. Thereafter, I reiterated that I did not want to disturb their normal workdays, but to be able to ask them about circumstances that I did not understand. The degree of participation when doing observation is a relevant question, but it is likely that it will vary during the study. Fangen (2004) claims that the most common approach is to be a partly participatory observer.

The knowledge workers I have studied were often under a lot of stress, and a new element that would ask many seemingly silly questions was not that welcome with a high stress level. Therefore, in the beginning of my stay at the companies, I tried to be relatively silent until they had adjusted to the situation and I understood more of the daily life at the projects. For the project participants, it was also about trust and getting used to the situation of having a researcher present. Hence, I tried to be open minded, positive, a good listener, and a constructive sidekick at the project facilities. Fangen (2004) calls such approaches a help role during the fieldwork, where the ability to switch between roles could be important.

During the field observation period at ITcom, the project manager made it possible for me to occupy a small desk at the project room where the major project participants had their work desks.[4] At first, I had the desk at the entrance, but half way into my period I had to change places because

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[4] In the appendix, there is an overview of who participated in my study, with names and roles defined in the various companies.

of one other people in the project team was going to cooperate with the person sitting next to me. I then had a desk in the centre of the room, and could follow or ‘supervise’ the other five persons, which put me in a very nice position to ask clarifying questions and make small talk. Due to the high pressure in ITcom, I could not and was not allowed to take the project members out of their project context to do interviews, but I did ‘small interviewing’ through small-talk and lunch conversations. It was also very easy to join their meetings, since it only involved following them to their meetings and taking part since I then knew when meetings would be held.

The situation at Calculus was slightly different because I was assigned an office at the project area of NEST. The team members had cubicle offices assembled at one end of a corridor, whereas my office was at the corridor entrance. Therefore, I had an overview of who left and entered. However, since it was a cubicle regime, I did not have similarly intimate access to observe daily work like in ITcom.

At the end of the corridor, there was a relaxation area with sofas and a coffee table. Many internal meetings and informal gatherings took place there. Therefore, I spent a lot of time on the sofa writing notes, and the spot contributed to an enhancement of my understanding of the environment. In addition, it was a good place to discuss elements of the project with the engineers. Since it was mainly a recreation area, I was able to ask all the ‘silly’ or obvious questions about their work without feeling that I disturbed them too much. We did also discussed many other things, like football, cars, music, children, food, and so forth.

During the period of my study, the NEST team gathered to test the system at their test laboratory. Fortunately, I was able to observe and participate during the test, which gave additional information about the team and its work. It was very interesting to follow and to do testing, but it could also be quite boring. Some of the engineers were not interested in taking part, but had to, and this created some tension. Others thought the intellectual challenge in finding out why the system crashed was fun. The project manager worked hard during these test days to motivate the participants and to push the testing forward. It was an important period in my study, because I got a much better understanding of the project members when staying with them all day in the same room.

Often, when being out in the field, it is important to get access to meetings. However, it can be challenging to get information about meetings. This information is not communicated to the researcher because those we study do not know that we would be interested in taking part. This was also Law’s (1994:44) experience. Therefore, key informants or gatekeepers are very important to the field experience. My gatekeeper at the NEST project was the project manager. His support and help with arrangements made the field period very fulfilling.

A year after my main study of NEST was over, I went back to the project team to present some preliminary results and to discuss their project and how it evolved. It was a great experience to be able to discuss and present my interpretations of their work with the team. They had important amendments and small corrections to my work.

To do participant observations is about what you see and what you do not see. For me, it has been important to describe the workplaces in a thorough manner. The outside and inside of the buildings, reception areas, and group areas, offices and lunch facilities have caught my eye. Buildings or surroundings do matter, and how the companies chose to arrange their facilities has been a cornerstone in my way of approaching them and the way they stage knowledge-intensive work. In the same manner, I have also observed how the knowledge workers look and behave during work. However, since they did not act that much differently from me, it was a greater challenge to see beyond the obvious and the ordinary. When doing observation, the things that stand out are the irregularities, and it may be unfortunate that irregularities steal one's attention. Nevertheless, it is hard to avoid, except to bear it in mind. Silverman (2001) claims that cultural studies research neglected to study how people use different visual and mechanical resources in their surroundings. However, this is what I tried to do.

When you become a part of other people’s daily lives, it is also important to remember to treat the gathered information in a careful manner. Fangen (2004) underscores the importance of handling with care the confidentiality of those who inhabit your field sites. It is very important to respect the people we study and to remember that we are guests at their territory. However, this does not mean that we should not have critical distance, which we need to use to analyze our data. After the collection of data, I have started to write stories about the experiences from each case study (Hope 2002). This is something I have also done during breaks from the field. As previously mentioned, it has been important to describe features like buildings, people and working facilities. Further, I have analyzed and worked with the written descriptions. Often, through these efforts, I have found interesting questions to pursue. Of course, the interview material has been a part of the document base. My supervisor has also been important in the discussion work, where he has contributed advice and comments on the written pieces. Various colleagues have also read assorted drafts. In addition, I have presented data at conferences both nationally and internationally. To present and to let others read drafts is a way to expose your interpretations and thereby open up to different perspectives on the material. This, I believe, makes the validation of findings stronger. Previous research is utilized to shed light on one's owns findings, and interpretations are also a part of the validation process.

To summarize, to write about methodology is often to engage with norms about how to do the research the right way. Have we done the research in accordance with the rules applied in our field? Law (2004:41) points to the hinterland of research and argues that there is a need for a new language to talk about methods that would help us to recognize and deal with fluidity, leakages and entanglements. Further, the ethnographic method can be seen as a way to look at characteristics, where method is not limited to representation; rather it is crafting, allegory, or gathering. Another important point made by Law (2004) is that method is a product of realities rather than a reflection of them, where only parts of reality will be visible. Another point with respect to validity is the issue of whether informants give valid information (Fangen 2004). A period of participant observation may be helpful to enhance one's understanding of the environment and participants.

I have tried to give a broad account of my method and approach. Hopefully, this provides sufficient foundation for readers to understand the basis of my interpretations and the choices made, and thus also to assess the validity and reliability of the study.

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2

The Architecture of New Knowledge Factories: A Mode 2 Design?[5]

There is broad agreement that the ecology of the production of knowledge in contemporary modern society is changing, even if different concepts are used to designate the outcome. Catchwords like post-normal science, transdisciplinarity, mode 2, knowledge-intensive companies and knowledge-work (Funkowitz and Ravetz 1993, Gibbons et al. 1994, Nowotny et al. 2001, Drucker 1993, Alvesson 1995) have gained increased popularity as ways of describing the main features of a fast-growing, knowledge-intensive service industry. What they have in common is an emphasis on the production of knowledge as contextualised problem-solving, usually based on teamwork by a diversity of professions. Nowotny et al. (2001) also see Mode 2 knowledge production as based on increased openness and interaction with the public.

In order to understand these new forms of knowledge production, there has been some interest in the culture of such companies. The focus of these studies has been diverse, spanning issues like identity, story telling, dress codes, discipline, and forms of interaction. However, there has been little interest in buildings and architectural structures as important dimensions of the material aspects of new knowledge cultures. In many ways, Latour and Woolgar's (1986) ironic statement of the architecture of the laboratory they studied through the only photograph of the buildings is typical: 'A view from the roof'.

On the other hand, architecture is often read as a cultural statement. Normally, we would expect at least some functional relationship between a building and the activities that it accommodates. Thus, we should expect buildings to also be an important part of the knowledge work culture that may provide clues to improve our understanding of this culture (Cooper 2003:11, McGrath 2005). From a technology studies perspective,

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it would be reasonable to argue that the practice of knowledge work is embedded in and shaped by architectural designs (Bijker and Law 1992, Sørensen and Williams 2002).

In this paper, I will pursue these ideas by exploring the interaction between knowledge-work and building structures in three Norwegian knowledge-intensive companies. More particularly, I want to see if the architectural design resonates with and/or provides new clues about the characteristics of knowledge-intensive work outside traditional research institutions.

To clarify some of the underlying issues, we may briefly consider some features of the *Domus Media* building at the University of Oslo in Norway. It is the grand edifice in the middle of the University Square surrounded by Domus Bibliotheca and Domus Academica. The Domus Media, Bibliotheca, and Academica edifices were constructed and finished in 1852. They were among the first buildings in Norway dedicated to university purposes. These buildings were placed at Oslo's main boulevard, Karl Johan Street, between the Royal Palace and the Norwegian Parliament. The placement adds symbolic power to the university buildings (Østerberg 1998:30, Gabrielsen and Saugstad 2005). Domus Media has a portal that consists of four Ionic columns, which are fluted and have capitals constructed of volute and echinus. This impressive portal is a remarkable signal to the public about the importance of the building and the activities at the university.

The heavy and monumental design reflects the elite status the academic community had, placed in the centre. At the same time, the building's facade reflects the trend that dominated design and architecture in that period. Perhaps we may say that these buildings represent a special vision of how to look at knowledge. In my view, they are typical examples of a design reflecting traditional academic research, what Gibbons et al. (1994) call Mode 1 knowledge production. This mode is characterized by a specialized, discipline-based approach, with substantial autonomy as well as authority in its otherwise open interaction with society. This could lead us to expect that Mode 1 architecture would be characterised by open access to the buildings with few restrictions to entering, symbolizing accessibility to the university and its knowledge. The 'open-door politic' is a form of a public proof (Nowotny et al. 2001). For example, 150 years ago all lectures at the University of Oslo were, in principle, accessible to the public, and lectures were advertised and reviewed in newspapers. Even if education were a limited good and it might require substantial social capital to enter.

Building design is influenced by economic constraints as well as various cultural and social needs. However, when Norway was still a rather poor country 150 years ago, the government prioritized to build a mighty university to symbolize the importance of knowledge and education in society (Brekke et al. 2003). The first university buildings in Oslo are Empire constructions in a strict and harmonic classic style, and were architect-designed by Christian H. Grosch (Seip 2001). The main building has a temple portal with a Greek antique inspiration. Grosch had a clear vision of why he used the Greek style, writing in a letter:

> These edifices, which are decided to scientific purposes and to pursue progress, will therefore appear as eternally valid, and Greek is the preferred style in preference to a newer style.[…] Public buildings are monuments of the time when they are constructed, and they have the same function as a mirror, to reproduce the spirit of the age (Seip 2001:145. Author's translation).

Grosch felt that the Greek style would give the buildings a more antiquated expression, and thereby more monumentality. The excerpt above exemplifies the hope for and expectations of the new university. However, it is also a manifestation of how buildings were seen as important statements. The 1911 history of the University emphasized that the buildings constructed in 1850 provided the opportunity to teach with basis in practise and experiments, where scientific institutes and collections supported the teaching (Gran 1911:230).

Portal of Domus Media (Photo: the author)

The university buildings in Oslo were built as monumental edifices to pursue scientific purposes. They are examples of a design where the main reference point is from other European knowledge institutions, and the function of the buildings had great influence on the exterior and the chosen architecture (Aslaksby and Hamran 1986, Brekke et al. 2003, Arnold and Bending 2003). Buildings are attributed a certain meaning from their surroundings. These edifices reflect the ability of humans to change the surrounding landscape by building massive, yet beautiful, structures. Domus Media, both from the outside and inside, is a powerful symbol for knowledge and the meaning ascribed to scientific and academic work. These edifices were typical models of the right way to design buildings for academic purposes (Markus 1993).

Applying a Mode 1 (Gibbons et al. 1994) understanding would involve looking at the organisation of the university buildings to discern what the outside structure tells about the relatively high value of knowledge. The inside structure also tells a story about the importance of knowledge and sharing it with the public through accessibility. For example, the Domus Media was designed with an impressive reception area and an open staircase to inspire people to enter and seek knowledge. The professor's offices were large and furnished with heavy and homey furniture. The auditoriums were designed rather modestly, while an experimental laboratory was placed in the basement. The building also contains a medical theatre auditorium where the public could observe medical lectures. Arguably, the necessity of separate rooms to perform the diverse professions and represent different bodies of knowledge seems to give evidence of a Mode 1 quality of the architectural designs.

The argument above suggests some possibilities for relating particular qualities of academic work to features of the buildings in which these activities take place. But what should we expect when looking at knowledge-intensive companies outside of academia?

Cultures of new production of knowledge

Buildings are products of human efforts. In the construction phase as well as during the building's utilization, there are various considerations concerning technological, social and cultural options for use (Ryghaug 2003). How is it possible to analyze a building as both a fixed structure and an object that is used and to which meaning is ascribed? Lynch and Woolgar (1990:13) argue that objects and representations are interconnected, whereby objects can only be known through representations. Buildings can be seen as objects of (re)interpretation: they tell stories and form a representation when we deconstruct the buildings materially and semiotically, as Gieryn (2002) emphasizes.

Gieryn claims that much of what has been written undermines the simultaneity and interplay of structure and agency in buildings. It is possible to see buildings as statements. The focus in this article is office buildings, or non-residential buildings that are objects of human agency, and perhaps are also agents of their own. What are the implications of this?

Kornberger and Clegg (2004) state that buildings as organizing arrangements may enhance some activities and prevent or discourage others. A generative building organizes communication, knowledge, and movement. Potential use and the concealment of opportunities may also be a part of the social relations and practices performed in buildings. Gieryn (2002:45) utilizes various concepts from constructivist studies of technology to get to the more abstract concepts of structuring and reproduction that are more appropriate as a point of departure for empirical studies. These include concepts such as heterogeneous design, blackboxing, and interpretive flexibility. Like any other technical artefact, Gieryn argues, buildings are sites where people act, but at the same time become structured by the physical structures. With Jasanoff (2004), we can say that knowledge-intensive work and the buildings where it takes place are co-produced - or rather, that *knowledge about* knowledge-intensive work and such buildings are co-produced.

From this perspective, we should note first of all that the buildings that host knowledge-intensive companies may not have been built for that purpose. Since buildings have limited malleability, it may be that we have to be concerned mainly with indoor structures. Second, much of the academic knowledge about knowledge-intensive work may not be relevant – may not even be known – to those who have shaped the work space of the knowledge intensive companies. This makes it important to talk to people actually employed by these companies to get their impressions and points of view.

There is a large body of research that has been concerned with the culture of knowledge-intensive work. Two strands of effort should be particularly noted. On the one hand, approaches in science studies have explored the broad epistemic practices of scientists and engineers (for example, Latour and Woolgar 1986, Traweek 1988, Knorr-Cetina 1999, Collins 1985). On the other hand is the knowledge management literature and related studies (Nelson and Winter 1982; Drucker 1993, Alvesson 1995; 2001). With respect to knowledge-intensive companies, the latter strand of research appears most relevant on the surface. However, I have chosen mainly to draw upon Gibbons et al. (1994) and Nowotny et al. (2001) since they make particularly useful inferences about features of knowledge-intensive work outside academia – what they call transdisciplinary or Mode 2 type of knowledge production.

Mode 2 knowledge is created in a great variety of organizations and institutions. Knowledge production takes place not only in universities and in colleges, but also in non-university institutes, research centres, government agencies, industrial laboratories, think-thanks, and consultancies. As their point of departure, Nowotny et al. (2001) discuss the emergence of more open systems of knowledge production through Mode 2, based on the growth of societal complexity and uncertainty. Science may speak to society, but increasingly, society also speaks back to science. Or, more generally, the production of the Mode 2 type of knowledge takes place in a situation where there has to be dialogue between producers and users of knowledge.

This assumption is related to the claim that knowledge needs to become socially robust, which is achieved only when the process of knowledge production is transparent and participative. Nowotny et al. (2001:19) state that Mode 2 knowledge production is done within and between open and shifting boundaries, which implies more complexity with a Mode 2 situation.

To summarise, the argument of Gibbons et al. (1994) and Nowotny et al. (2001) is that the new way of producing knowledge – Mode 2 – is characterised by:

- interdisciplinary teamwork, engaged in contextualised problem solving
- communication of results to clients or the public, not to peers for review
- increased transparency to achieve social robustness
- increased engagement in public proofs and the performance of dialogue through the Agora, the metaphoric marketplace for the exchange of ideas.

If this is an accurate characterization, we should expect to find that buildings that accommodate knowledge-intensive companies are designed to facilitate open interaction with the outside world, as well as teamwork and open, interdisciplinary exchange within.

How to represent and visualize the building experience

When observing how knowledge workers determine location, it was necessary to be present at their business premise. Therefore, I will discuss what one does when observing both the surroundings and use of the premises as visual research. Emmison and Smith (2000:55) claim that visual research can become a powerful and theoretically driven activity of social and cultural inquiry. It is necessary to go beyond images and pictures if looking at locations as total environments, as objects that people interact within. A location can also be seen as the spatial context for understanding objects, turning from objects to physical location and not only as objects where people interact with each other (Emmison and Smith 2000). My goal has been to go inside the buildings and analyze the surroundings as well as the context. Spatial considerations need to be in the forefront of the investigation, and the method I have used is direct observation in workplaces, which is a naturalistic setting.

Further, Emmison and Smith (2000) criticize ethnography for not taking into account the matters of place and space. Through participant observation, researchers are only listening and not looking at the environment. Silverman (2001), on the other hand, points to a relative neglect in the research regarding how everyday participants use the visual and mechanical resources in their environment. According to Sacks (1992:87), it is the classes and categories that you encounter that permit you to see and analyze the sight. The question is how participants view location. It is necessary to be present to encounter patterns of how they use their space. Therefore, as Suchman (1987:28) observes, it is necessary to look at the user and the local interaction as contingent on the actor's particular circumstances.

I have studied three knowledge-intensive companies. Two of them are in the software industry. The third is an applied research institute that also provides research based services. I have done fieldwork, combining interviews and observation. The goal was to study activities and localities in a particular setting (Smith 2001:220). It was necessary to observe *in situ* what knowledge workers were doing at their location in order to understand the utilization of the premises. The focus of the study has been on everyday work practices, in addition to describing the work environment in a practical manner. The interviews lasted between 45 minutes and two hours. They were taped and transcribed in verbatim.

The first company, ‘Calculus’, is a mid-sized software business situated in Oslo. Here, I observed one project team periodically over a year and a half. I interviewed 21 people, including conducting two group interviews. I have given the informants different names to safeguard anonymity. Those who worked on the team called the Nest project were given names beginning with E, while informants from the rest of the company have names beginning with K.

The second company, ‘ITcom’, is one of the bigger consulting companies in the Norwegian software industry. I was given access to a sub-division office in Bergen, which employed approximately thirty software engineers. The fieldwork was done throughout May and June of 2002. I participated in the everyday practices of a project called Ark. This was supplemented by three interviews with managers in the firm. Team members of Ark were given names beginning with M.

The applied research institute, ‘IFOS’ (which is an acronym for ‘Institute for social research’) was located in Trondheim. It has several departments, two of which - ‘Department A’ and ‘Department B’ - I studied. The latter had a subdivision in Oslo, which I label ‘Department B2’. The data from IFOS was collected periodically throughout 2000, 2002 and 2004. I have done 11 individual interviews there, in addition to two group interviews. The informants from Department A have names beginning with L, whereas those from Department B and Department B2 have names beginning with S.

The empirical analysis is based on my observations of the buildings and the environments in which the informants work. This is supplemented by the interviews, which have also been used to look into how the buildings are used and experienced by the employees.

The modest witness or nothing out of the ordinary?

The introduction provided an example of how older university buildings constituted large and impressive edifices. Law (1994) also tells about grandness in his laboratory ethnography, where he interpreted a huge tower building as a massive statement about the importance of science. Within modern or more functionalistic architecture, there is also room for a monumental expression, such as a large sacramental form and large gable windows (Jørgensen et al. 1980:144). The monumentality would be materialized by utilizing simplified building materials and grandiose building sizes.

However, the buildings I encountered during my fieldwork were quite different. The IFOS research institute building in Trondheim was large and quite new. It had a facade made of red bricks, and the construction noticeably used windows as an embellishment. The construction consisted of two separate buildings that were linked by a glazed bridge, which added an airy and futuristic touch to the edifice.

The IFOS building in Oslo was located in a science park. Here, the buildings had a functionalist style, often made of brick, quadratic office blocs, and the colours used were grey, brown, beige, and pale pink. The IFOS building went along with the functionalism. The functionalistic feature was also apparent at the ITcom office in Bergen, which was situated by one of the highways leading into the city centre. The atmosphere here was nearly like an asphalt jungle, with greyish, simplistic, basic, functionalistic style buildings. ITcom rented the top floor of a quadrangular, medium sized office building. It was a whitish coloured brick building, four floors high, with windows in four rows at the two long sides of the building.

Calculus was located in a business area in Oslo. When you get there, you pass an alley with similar, tall, dark coloured, modern edifices. Calculus rented fours floors in a rather new office building. It was a medium sized building, housing Calculus and a few other smaller technology firms. The building had a modern look, with using glass and white facade wallboard.

All these buildings were very different from the style of old university buildings and could rather be characterized as modest. The buildings accommodating these knowledge intensive companies do not distinguish themselves from surrounding office blocks. Clearly, they lacked the symbol-saturated expressions of traditional science buildings. This supports the claim that Mode 2 knowledge production has become commonplace. This production of knowledge is like any other office work. But what happens when we enter these buildings? Do they welcome visitors from the public?

Absorption centre

The first element you encounter when entering the buildings is a reception area. One might think about this area as an opportunity to do impression management, to seduce guests into the right mode. Of course, to have a nice environment that greets guests is not a new idea. An early example of a kind of impression management strategy may be found in the 1830 project description of the University of Oslo :[6]

> The buildings ought to give an impression of the nation's recognition of its high value to science and enlightenment (Aslaksby and Hamran 1986:16. Author’s translation).

This document also states that the vestibule is the first place a visitor will see. Therefore, the entrance ought to be decorated with style and care; it should not give a simple and poor sense of the university. University buildings have open access, which also supports the Mode 2 understanding of the Agora (Nowotny et al. 2001), in which the public has the possibility to participate in open exchanges. Does the welcome area in the various knowledge intensive companies I studied have something similar?

The first reception area I visited was in the IFOS building in Trondheim. Visitors enter this building through sliding glass doors, and a reception area welcomes the visitor. Behind the reception desk is a service-minded person who records the visitor’s name, institution, time, and the person s/he is visiting. Then, the receptionist calls your appointment. Until somebody comes to accompany you into the building, the visitor would wait in a small recreation area with a sofa, two chairs and a table. Across the corridor, an open door led into the institute’s library, which looked like a part of the welcome centre. This could be intended to give visitors a message about IFOS’ eagerness to present their identity as a knowledge-seeking research enterprise. A sign in the entrance area explained the way to their auditorium, which linked IFOS to a scholarly world of lecturing.

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[6] Due to the union with Denmark, the University of Oslo was called The Royale Fredriks University until 1939.

Crossing the intersection bridge between the two houses, the visitor would arrive at the entrance of either Department A or Department B. However, the accompanying staff member would need to unlock the door before entering. Otherwise, if crossing the bridge alone, the secretary at the office next to the entrance door would let you in after checking from the large window facing the entry. When entering, there was a service area containing a wardrobe and toilettes available for both departments. Following the welcome procedure, the visitor gets an impression of the company as solid, effective, and above all, as secured. There was only one entrance to the buildin so that visitors could be controlled and access limited. No admittance, except on business!

Arriving at the ITcom building, visitors take the elevator to the third floor and ring the bell outside the entrance. During the last year the staff has been downsized, and among those who where dismissed was the secretary. Therefore, when ringing the bell, the consultants have to open the door manually for visitors, which before was a secretarial duty. During my observation period, it was often necessary to wait and ring the bell repeatedly before anyone opened. To wait can be rather annoying for visitors, but it was possible to spend the time looking through the glass door. The first thing you saw was a banner proclaiming that ITcom was ‘Building the information society’.

When entering the office area, there was a modern waiting space for guests. This consists of a blue, oval, lounge-suite and a coffee table. Newspapers and periodicals lay on the modern table. Different framed posters from ITcom's various advertising campaigns were hanging on the wall behind the sofa. In addition, a framed certificate from an accreditation company decorated the wall. The reception desk was located behind the lounge sofa. The desk was painted blue, with stainless steel details. The light colours on the wall and floor supplied freshness.

Once a staff member opened the door for the visitor, he or she followed the visitor either to a meeting room or to the person whom the guest was going to visit. Therefore, they were not using the welcome zone very much. The routines for answering the phone and welcoming visitors were a bit unsystematic.

In fact, the design of the reception area at all four work sites was fairly similar. Nice, modern Scandinavian furniture inhabited the waiting areas, together with light colours on the walls and floor. This added a clean and professional appearance to the companies’ frontstage (Goffman 1959), and functioned as an impression statement to guests (Berg and Kreiner 1992, Clark 1995). A striking similarity is also the way in which the reception areas are set up to control visitors. In fact, access is restricted. It is difficult to get in unless you have an appointment and a contact person.

We should perhaps not be surprised about the restricted access. These knowledge-intensive companies do business; they need some level of security and to be able to receive clients and other guests in a way that guides visitors quickly to the right place. The open access of universities makes it more difficult to find your way around. However, the restriction of access and control of visitors through the design of reception areas also signifies a limited access to knowledge that has become a commodity (Amdahl 2005:173).

Entering the cubicle prototype plant

To study how knowledge intensive companies utilize their premises, it is necessary to enter their office space. Do we find an architectural design made to support teamwork and interdisciplinary exchange, according to the features expected from Mode 2 businesses?

At Calculus, I followed the work at the Nest project area. The project team was located together at the Calculus building. During my observation period, the Nest project consisted of approximately ten software engineers, including the project manager. The Nest group was a well-established team, although occasionally there was some replacement of personnel. Most software engineers in Nest were working mainly for this project; therefore, the group was quite stable, even if they moved among different tasks. Einar, one of the Nest project members, compares Calculus to a firm where he had worked before:

> My previous employment was in a kind of line-staff organization, but here we are organized in various project teams. People are moving around to different projects and are changing offices. It is the company's ideology to share knowledge, but all the same, sharing experience is something we do.

Changing from one project to another also involves a physical relocation to achieve proximity to the new team. The Nest corridor consisted of different sized cubicle offices. The offices were one-person rooms, with bright and modern furniture: a desk, PC, a shelf, and a swivel chair. The offices were not spacious; there was only room for one desk and one or two shelves. Every office had a window at one end and a glass wall and a glass door towards the corridor. This added brightness to the offices and the corridor, as well as a transparent expression (Duffy 1997). Their office doors were open almost all the time; the door seemed only to be shut when the engineers wanted to concentrate or talk on the phone. The openness made it easy to ask colleagues for help or to have a chat.

Most offices had a rather impersonal look, with few personal belongings, pictures, papers, or books. In spite of the cubicle-designed offices, Nest project member Egil talked about their work as individualistic, but at the same time:

> Our work is often solitary, in front of the computer, but it is not disconnected from the other project member's work. We drop in at each other's all the time, and talk together. We share experience, tip, and advice. It is important sharing competence and experience.

Endre, a new and inexperienced engineer, also emphasized the importance of cooperation with experienced colleagues:

> I walk over to his office and ask him for help. We discuss how we are going to divide the work between us. He is very experienced, and it is truly a short distance between our offices. We do not sit solemnly in our cubicles and work alone; we run around and profit from the diverse experience people have.

In spite of their cubicle life, the project team did collaborate and share experience. It was important to discuss the development work, and the group had a relaxing area with sofas where the conversations were often related to work. There was also a meeting room in the corridor, but it seemed that they preferred to meet at the more informal sofa area. They used the meeting room for client encounters and their weekly summary meetings.

Many system design projects move to the client's premises to do the development work. However, the Nest project group was located in the Calculus building, which meant that the client and user representatives had to visit Calculus to participate in meetings. The software engineers in the Nest project stated that they worked better when there were few disturbing elements at their office premise. They claimed that users could lead to more turbulence. Endre explained how the location was influential for his own development as a Calculus designer:

> I think it is a great strength that we are located together at the Calculus building. The engineers who work elsewhere have less ownership or loyalty to the company, and perhaps it will be easier to change companies.

The Nest group had a nice cubicle corridor and a welcoming gathering point. The colours utilised on walls and floors were bright, and the wall was decorated with mellow watercolour pictures in silver frames. In addition, various diplomas that the Nest group has obtained in internal competitions 'decorated' their front door. However, the layout did not enhance collaboration among the engineers. Even so, the engineers frequently dropped by other's offices to ask questions, socialize, or help with a problem. There was only one other project at Calculus where they had made a conscious choice regarding the design of their office. The project manager, Knut, explained this in the following way:

> We decided at the start of this project to organize a project office. So the four of us have arranged our desks as a four-leaf clover where the computers points into the middle of the clover. We have some small tables at the side to unload the main desk. We face each other, and it is very easy to talk. The easy communication is both a good and a bad thing. Sometimes we talk too much about a problem, and other times we talk too much about social events.

Knut's project engaged only four engineers and their conscious choice about the project office was a new way to organize space at Calculus. Knut felt that the project room enhanced the collaboration and communication between the project members, although he added that he had been deliberate in selecting the right people. Knut based his selection criteria on programming skills, but also their ability to work in a team.

The cubicle architecture does not enhance collaboration (Duffy 1997:63), although organizing for collaboration was one of the assumptions about Mode 2 architecture. Even if the cubicle office design hampers close collaboration, the Nest team felt that they enjoyed a rather open space and the opportunity to work together when needed. It was a rather high degree of transparency at the facility, due to the use of glass doors and walls at the corridor end of the offices and through close following up of the project work at their daily and weekly meetings.

To share the ground

In line with Kornberger and Clegg (2004), it is possible to claim that office design as an organizing arrangement can enhance some activities and prevent others. There is reason to believe that a generative office could contribute to organizing communication, knowledge, and movement (Duffy 1999). Potential use and concealment of opportunities can also be a part of the social relations and practices. How will Mode 2 assumptions about shared space work in a smaller project office?

The project office at ITcom. (IKEA office planner tool)

ITcom occupied an entire floor in an office building. The reception and welcoming areas were at the rear end of the premises, together with a meeting room and service rooms. From the reception area, two corridors led to the offices. In the middle of the area, there was a larger meeting room. Perhaps it is possible to name this type of office planning the 'hospital rinsing model' (Larsen 2005). The offices (like patient rooms) had windows, whereas the service areas were in the middle of the building with no windows. Many engineers at ITcom had single cubicle offices, others shared and office, and there were two project rooms with work space for three or more people.

The Ark project went through a hectic period during my two months of observation. The project was making a new system for e-learning for a larger Swedish company, and the Swedish division of ITcom collaborated with the Ark group to develop the software. Of the seven people on the Ark team, four shared the project office and the other three had single cubicle offices. The cubicle inhabitants often came into the project room to address the group or talk to one of them about urgent matters concerning the project's development.

During the observation period, I was allowed to be the fifth person in the project office, in addition to participating in their internal meetings. The project room was a quadratic, medium-sized room with network connections for four persons. There were desks placed at the three successive walls in the room, and the latter wall contained a door and bookshelves. Only a few books, development manuals and some folders filled the bookshelves. The consultants used one of the bookshelves to divide the room, which created a protected area behind the door. In addition, the room was bright because of large windows fronting one wall. Although the room had a functional and modern style, which was enhanced by the light wooden office furniture, light colours on the walls, and ergonomic swivel chairs. It seemed more important to have a functional workspace then a stylish one. For example, papers and manuals were gathered around the PC's, together with different personal items.

The following incident is indicative of the office atmosphere. Maria and Marius started a low-voiced discussion when Maria transferred some tasks to Marius:

> Maria to Marius: How are you doing with your assignment?
>
> Marius: I'm doing fine, but this is not a high priority task. Do you want some help?
>
> Maria: Yes, that would be great. I really have a lot to do, but have not managed to finish the design of the new group. Could you possibly start that development?
>
> Marius: Yes, of course. Just send me the requirement specifications.

This conversation was typical of how they cooperated. If there was a task that was more urgent than others, then it was alright to ask for and get help from other team members. The group had low-voiced conversations during the day, asking for help, talking about different tasks, socializing, chatting about colleagues, family, and other topics. Besides the status meetings, the project room was the formal as well as the informal meeting place for the whole project.

Code writing and system design have often been perceived as rather solitary tasks (Weizenbaum 1976). However, from the observations in the project office it was obvious that the software engineers collaborated a lot during the design process, although they had different responsibilities and tasks. I had an expectation about Mode 2 architecture that would facilitate a more transdisciplinary work atmosphere by enhancing communication and co-operation. The impressions from the observation period at ITcom are mixed in this respect. The ITcom office premises, with its cell design (Duffy 1997), seemed to invite to individual, perhaps disciplinary work. In practice, a Mode 2 culture emerged through teamwork, networking, and cooperation at the project office.

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Space for play and cooperation?

At IFOS in Trondheim, applied researchers from many disciplines take part in project work, but the departments vary with respect to research focus and methodologies. They also designed their offices premises differently. I observed and interviewed at Department A and Department B. Department B had a subdivision in Oslo, which I have called Department B2. Thus, the following outline concerns three different localities.

Ludvik started to work for Department A, but lately he had done a lot of work for Department B. Therefore, he had been reflecting a bit about how Department A has designed their office environment:

> During the day, the surroundings are structuring our interactions. […] We should persuade Department A researchers to come out of their cell offices. Alternatively, another solution would be to have some project offices where people from the same project work together. At Department A, the structure and architecture of the offices enhance individual performance.

Department A had designed their office premises after a traditional cell office model (Duffy 1997). Ludvik experienced this model as restrictive for collaboration, which he felt was important for work performance.

The design solution at Department B was slightly different. Their corridor had been opened up to the form of a semi-open office landscape with a big common space in the middle and very small cubicle offices situated at the walls. The cubicles only had room for a small desk, a chair, and a window. Sliding glass doors shielded the inhabitant from the open space. Therefore, it was possible to take part in what was going on in the open space, or work alone protected by the doors. These offices had rather stable lodgers, but there were also some bigger offices, which some of the more senior researchers occupied. In the common space, a sofa was the centre at the far end. In the middle, a group of office desks were placed in a circle. Department B used the place for team activities during project work or as workplace for guests. Up front, there was a slim, tall table. At the table, one could stand and talk, read newspapers, and enjoy fruit from a basket, so in reality, they used this space for recreation and small talk.

When they moved in, Department B made a conscious choice to design their office as a landscape, but also implemented some elements from the more one-man one-office design. An experienced researcher:

> In the beginning I was quite sceptical about the open landscape, but I have grown accustomed to it. The collective arena is very important to me, and we are working as a group hanging around the bar table, the switchboard, discussing and thinking together. Now, when we have the possibility to work in a different manner, we also utilize the constructed opportunities. (Svein)

Svein was convinced that the new office model had influenced working habits and cooperation. They have also started working with projects about knowledge work spaces for clients.

According to my informants, they discovered that it was important to have flexible spaces. Ludvik, the researcher who had worked for both departments, remarked:

> I believe that one needs to do things that are noticeable, and these changes have to be real and material. Department B has done some specific changes; for example, through the manner in which they have designed their working ambience. These processes have underlined their goal to achieve changes towards more collective processes.

When asked whether changes had to structural, Ludvik continued:

> Yes, I think one needs to do things, carry out some symbolic changes not only talk. It is important to realize material changes. The structural changes are a help to continue the conversations about changes. Organizational changes are about initiation of new conversations to implement new ways of doing our job – a new practice. The symbolic changes are a help in the change process.

Making changes is important to Ludvik, and he is concerned with how changes are set into motion. In a way, the new office solution for the Oslo subgroup, Department B2, was a structural change.

When Department B2 moved into the IFOS facility, they chose a very new and innovative office design. Department B2 contacted an architectural firm with competence in office design to supervise the development of the facility, but they also had their own project group take part in the development. The new design solution was very different from other departments in the IFOS building. Samuel, the head of the department, emphasized that they themselves had provided services related to the workplace and the design of new ways to work. He continued:

> We are sophisticated users since we have studied this and I think we have found some good solutions for us. However, it was a transition for us to work in an open office landscape. One needs to learn how to use the openness.

Samuel presented the different criteria, which had been important for the development of the office design. He highlighted the intended built-in flexibility at the facility; for example, open spaces that could be rearranged to fit new needs. One important principle for them was to have a computer-based archive that the staff could access in order to use less paper and space. The next principle was to have only a few personal things at work. Each employee had one shelf available for their books, and books should be available for all. This was a democratic way to restrict the use of the public space, but also an opportunity to share different professional literature. As Samuel emphasised:

> It is important to have a mutual reference frame, a common identity, mode of expression, and all of this can be facilitated. Work is primarily a social activity, and one can arrange the physical environment in many different ways. However, one needs to add a bit of aesthetics, enchantment, and drama to the office.

Although there are different types of knowledge intensive work, Samuel claimed that it was possible to utilize the same approach when designing office facilities. Further, he explained that they divided their facility into different work zones.

The first zone was the entrance zone, where a small corridor led into the ‘public’ area, designed to ‘entertain’ guests. It was possible to redecorate the area to suit different needs, to make it suitable for meetings or lectures, for example. The next section was a more closed zone with two small rooms and a corridor leading to the first office landscape. Here, the first room was a playroom or a creative meeting room with cushions to sit on, a few low chairs, some toys, balls, and some Lego to play with. One wall was painted fresh green, perhaps to enhance the creative spirit in the room. The following room was a small meeting room with an oval table and a couple of modern cane chairs. In comparison to the playroom, this meeting room had a very clean and neat atmosphere.

Further, the first office landscape consisted of a big table that was an assemblage of four office desks. This was the work area for a group of four, where there were PCs, telephones, a fax machine, and two smaller meeting rooms available. The walls between the open spaces were used as a notepad, with notepapers taped to the wall. Department B2 rented the zone to a group from a different IFOS department. Samuel explained that to let somebody rent this space was one of their ideas about their new facility and its flexibility, which appeared as a mantra or value in itself.

Passing the archive, the next section was a pleasant library and gathering space with some relaxation chairs, colourful quadratic pouffes, a coffee table filled with magazines, books, different advertising leaflets, newspapers, and some of Department B's own publications. At the end-wall, bookshelves were filled with the staff's different books, mostly scientific publications. Next, the corridor vanished and opened into a spacious inner room. Both sidewalls had windows, and therefore the light was quite bright during daylight. The office desks were spread around the room in clusters of two or four adjustable desks. There was room for 12 people working there, but it was possible to fit more people in.

The office landscape at Department B2. (IKEA planner tool)

Employees had their own waist-high rolling locker for personal belongings, papers, and other things, and it could be moved to the desk for the day. The standard praxis was to use the same desk more or less on a regular basis. Sol said that their thoughts about flexibility had been a big issue in the internal design project. In reality, Sol did not experience much moving around:

> One is supposed to move around according to one's various tasks, bringing the computer and telephone and utilizing the designed flexibility. However, there has not been much moving from desk to desk lately. I think the greatest challenge was to let go of a big solitary office. We are concerned about how to use all the available space in a good manner, so that the space adds value to the process. We must turn away from a thought that you do not carry out real work when not sitting at your desk.

There were few private zones, and for Sol it was important to have some shielded spaces for doing concentration work.

It is interesting to note the diverse designs found at the IFOS departments, from the traditional cubicle situation at Department A to the Department B2 facility, where a flexible space was the goal for the design of the office premise. The intention with the anticipated flexibility was to have the ability to transform and adjust the space to different activities (see also Duffy 1997). In principle, the office design at Department B and Department B2 could be regarded as an approach to Mode 2 architecture. At both facilities, a possible temporality was built in the concepts of the office landscape with changeable space alternatives. However, the actual use of the landscape seemed to be more stable and structured than Mode 2 architecture anticipates.

Towards a Mode 2 architecture?

The Mode 2 concept has a strong rhetorical appeal (Elzinga 2004) in spite of its ambiguous empirical support (Amdahl 2005). However, for my purposes, the concept has been useful in providing a canvas to discuss physical features of knowledge production in various contexts. My intention was to see what kind of clues architecture could provide with respect to the culture of knowledge-intensive work. Was it possible to see workplace architecture as representations of transdisciplinary knowledge, knowledge work, or knowledge workers?

Mode 2 proponents have characterized the new trend by referring to catchwords like flexibility, teamwork, network, and cooperation. The question is whether these changes will materialize themselves through the architecture of the business premises. My expectation was that knowledge-intensive companies would choose architectural designs that facilitated transdisciplinary work through physical and spatial affordances that would enhance communication and cooperation, as well as dialogues with users and society at large.

The office facilities of these three companies do not much resemble the old university buildings presented initially. Clearly, they had no need for monumental expression and authority. The symbolic features were more in accordance with the ideas of Mode 2 architecture in the sense that they represented the idea that knowledge-intensive work is a common affair, a rather trivial activity that did not crave buildings of a particular, striking design.

My interpretation of Mode 2 was also that it would invite an architecture that was somehow user or client friendly, a space signifying open access to the public. What I observed in the buildings was that access was restricted and controlled. When access was granted, for example to clients, the reception areas were designed so that visitors would be guided to the right place and the right person, unlike the traditional university architecture which is open but confusing. Perhaps this represents a commodification of knowledge, where it is important to facilitate the relationship between provider and client while also catering to the potential need for security and restricted access? At the least, this contradicts the ideas in Nowotny et al. (2001) that Mode 2 generally leads to greater openness through the creation of Agoric spaces (see also Amdahl 2005).

The three companies in the study organized their business premises quite differently. Arguably, the way that they had chosen to organize their locations physically is an indication of the way they think about the organization of work. For example, the design of the office space at Calculus with the widespread use of cubicles suggests an emphasis on an individualised, discipline-based way of working that did not enhance collaboration between software engineers and clients/users. Also, ITcom was a company with specialized engineers, which the design of their office space reflected. However, from my observations in the project-office, it was obvious that the engineers collaborated a lot, which was facilitated by their multi-workspace project rooms.

At IFOS, office design varied greatly, from the cubicle offices in Department A to Department B’s semi-open office landscape to the very new and innovative landscape office at Department B2. The cubicles at Department A did not facilitate collaboration, but this was adequate for a work situation where they largely pursued specialised knowledge and individually- based problem solving.

Department B had changed their office design into something more landscape-oriented, with a big common space in the middle of their inner room and very small cubicle offices situated at the walls. They claimed that this change had contributed to more transparency and collaboration. Department B2 had implemented an office landscape where one of their main goals had been to organize the facility in a flexible manner. This implied that various zones of the office space were changeable to fit new needs. In an office-landscape, transparency is a very distinctive feature, where what people do will be visible in the different zones (Duffy 1997).

Both Department B and Department B2 had thus designed their office spaces to cater to collaborations and facilitate transdisciplinarity. This was an explicit intention. My informants claimed that the intensions were realised and that they found their office design functional. The employees at Department A as well as in Calculus and ITcom did not complain about the design of their office spaces, nor did they offer positive remarks either. Larsen (2005) underscored that the physical room is not a neutral and just structure. The physical space or room can, when related to social and mental space, contribute to stability and stable relations between social groups. Space is traditionally regarded as collective, external and neutral since the structure organizes activities. This will especially be the case when there is no question raised at the workplace about how the space is organized. Most of the observed uses of space in the empirical part of the article showed this automatic approach to space. The only place where space was an issue was at Departments B and B2, because they had space organizing as one of their products and themselves were 'guinea-pigs' for their own ideas on design for knowledge-intensive work.

I have no reason to conclude that one design is better or more efficient than another, and that was not the purpose of the paper. I was interested to see if companies that could be thought of as exemplars of Mode 2 production of knowledge worked in buildings and office spaces designed according to Mode 2 principles. In this respect, the findings are ambiguous. On the one hand, the two organisations (Departments B and B2) that expressed an intention to work in a transdisciplinary fashion had offices designed accordingly. On the other hand, I also expected the other organisations to have a transdisciplinary culture of knowledge-intensive work, but this was not quite the situation. While they definitively did problem solving in the context of application, they did so according to more traditional, discipline-based ways of working, and their office spaces were designed in ways that signified this. Maybe Mode 2 knowledge production is less widespread than indicated by Nowotny et al. (2001)?

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3

Dressing for Credibility? A Study of Accounts of Dress Codes in Norwegian Knowledge-Intensive Companies[7]

Playing badminton in suits?

New employees in a large international consulting company start by participating in a comprehensive training at the company's main education centre. An important part of this course is to familiarize new employees with the company's conduct and dress code. On a visit to the course facility, I observed a group of young men playing badminton during a break. They were dressed in white shirts and ties, with dark single-breasted suit coats and dark trousers. Their suits looked new and fashionable, not faddish. It was quite a sight to see these young consultants playing badminton in suits, and their appearance clashed with one's normal expectations of conduct, raising the questions of what can be expected in professional surroundings and what one might expect of a consultant. However, I later learned that to work for this company as a consultant meant to be able to wear a suit in any situation imaginable.

Why was this important? Why did consultants in this company need to be dressed in a quite formal manner? These questions came back to me during later periods of fieldwork in so-called knowledge-intensive companies, where I observed people doing similar work but clearly following different dress codes. Was the first company accidentally instilling a formal dress code, or did this in some way reflect a particular way of producing knowledge? More generally, one might ask if the dress code had any bearing on the authority of their knowledge, or was this a superficial phenomenon without any real relationship to the production and implementation of knowledge?

This paper is an effort to explore such questions by investigating dress codes and knowledge workers' perception of dress codes related to their work. Standard theories of science, like Merton's (1942) norm of

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universalism, demand that the body that makes knowledge claims should be deemed irrelevant to the evaluation of these claims. However, this norm is not followed (Lawrence and Shapin 1998; Traweek 1988; Kaiser et al. 2001). This raises interesting issues about the role of the body, including dress, with respect to the performance and evaluation of knowledge inside as well as outside traditional scientific institutions.

When you want someone to listen to what you say, is it possible to “dress up” the message? Latour (1987) suggests that rhetoric is important in how text is interpreted. One aspect of this is the use of modalities: expressions or utterances that modify or qualify statements about aspects of nature or society. A positive modality is an effort to lead a statement away from its conditions of production, thus making it more robust, increasing its credibility, and allowing the statement to have positive consequences (Latour 1987:23). Negative modalities are expressions that, instead of leading to an interest in the possible consequences of a statement, focus on how the statement has been produced and explain why it is weak or solid. Since clothes are statements to the world, they may work as modalities in Latour’s sense. To what extent is the case; how conscious are knowledge workers about the potential effect of their choice of clothes; and are clothes intended only as positive modalities?

Of course, knowledge workers’ choices of what to wear at work are a more complex matter than just the issue of modalities. Clearly, it is influenced by fashion as well as cultural norms about differentiation and belonging. Clothes are a part of individual performance of identity and the display of taste (Bourdieu 1996). Giddens (1991) claims that decisions about what to wear, what to eat or which play to see, are not only decisions about how to act, but also about whom to be. Identity is not an ascribed fate, then, but becomes dependent upon decisions that are both risky and reflexive, as underscored by Beck and Beck-Gernsheim (2003). The way one chooses to dress is a way to position oneself in a group. Green (2001) argues that one can use dress to demonstrate professional belonging, authority, and identity.

Clothes are often used to establish an image in a context. Bamin et al. (2001) say that the clothes we wear must be appropriate for the function and for the audience. To follow the rules and tradition for appearance can have different meanings depending upon situation, and the choice of clothing for different situations can signal membership. One can practice inclusion and exclusion by way of clothing (Green 2001:98). For example, the suit is a safe and stable uniform and it gives the bearer a professional appearance.

Clothes are also important as a way of displaying or achieving power. An important example is the so-called power dressing frequently found in industry and by administrators as a way of demarcating their positions and claims of importance through proper conduct and stylish attire (Kaiser et al. 2001). To use power dressing might give the knowledge worker a professional appearance, and it could convey an aura of authority. However, is this really so? Would such clothes actually work as a positive modality, as a strategy to increase confidence in the knowledge or competence of a knowledge worker? Or could the effect instead be a negative modality, in that the use of power dressing would be read as an explicit effort to provide authority or even as an expression that the knowledge has been produced in a business setting rather than on supposedly neutral ground?

Through the wardrobe?

It seems reasonable to assume that physical appearance has a part in getting people to listen to what you say. Lawrence & Shapin (1998:10) argue: “The body is indeed a culturally embedded, and cultural-constituting, signaling system, and one of the things the body can signal is the possession and reliable representation of truth.” From this point of view, how you represent a message or knowledge will have an important influence on whether your audience is going to trust what you say.

This argument is a critique of the widespread understanding of scientific knowledge as disembodied, often expressed through a focus on knowledge itself, rather than on the embodied way in which knowledge is produced, reproduced, and maintained.

> Such locutions are standard, well institutionalized in a range of academic practices, and rarely contested. Yet, to tell the truth, I have never seen a “disembodied idea”, nor, I suspect, have those who say they study such things. What they and I have seen is embodied people *portraying* their disembodiment and that of the knowledge they produce or the documentary records of such portrayals. (Shapin 1998:23)

Shapin continues his argument by analyzing myths involving the physicist Isaac Newton. Over the ages, he claims, the Newtonian myth of an ascetic scientist who did not care about clothes, food, or other everyday tasks has been told the same way. One presumption associated with ascetic scientists is that they think thoughts that are of much higher quality than the average scientist because he or she is not distracted by worldly concerns. This myth is, according to Shapin, an effective way to distance scientific functions from other, more mundane tasks that have lower status. Creating the perception of a distant and superior scientific field gives greater status to science and the knowledge produced by scientists. Shapin believes that scientific knowledge produces a distance between those who are knowledgeable and those who are not, and that this is reproduced through the myth of the ascetic scientist. This myth works to support and strengthen the outside world's belief in scientific knowledge. Today, while the authority of knowledge itself may have lost its power, it is possible to assign mythic characteristics to knowledge when few in a group possess this knowledge.

Arguably, the main effort of the field of science studies has been to provide insights into the way in which scientific knowledge is embodied in work practices and scientific cultures (Collins 1998, Latour 1987, 1999, Traweek 1988, Knorr Cetina 1999). This has helped to produce an understanding of science as culture, but observations of enculturation and embodiment do not work as generic modalities of scientific knowledge. However, the role of the body in the production and dissemination of knowledge, in particular the role of clothing, has received little concrete attention.

One exception is studies of "computer nerds", which frequently refer to their asceticism as it is expressed in their frequent neglect of bodily appearance (Turkle 1984, Nordli 2003). Weizenbaum (1976:116) offers the classical description in his analysis of what he calls "compulsive programmers":

> They work until they nearly drop, twenty, thirty hours at a time. Their food, if they arrange it, is brought to them: coffee, Cokes, sandwiches. If possible, they sleep on cots near the computer. Only for a few hours – then back to the console or the printouts. Their rumpled clothes, their unwashed and unshaven faces, and their uncombed hair all testify that they are oblivious to their bodies and to the world in which they move. They exist, at least when so engaged, only through and for the computers. These are computer bums, compulsive programmers. They are an international phenomenon.

The nerd myth resembles the myth of the ascetic scientist. Nerds are supposed to spend too much time at work. They are not healthy looking and rather unkempt. Related to that myth is the perception that this kind of devotion helps the world of computing progress. The ascetic ideal makes nerds separate as a group, to be seen as devoted computer experts. In this way, an ascetic or disheveled way of dressing may provide credibility as a knowledgeable expert.

Traweek (1988:25) observed that people in the high-energy physics laboratory she studied dressed differently according to their occupation and role within the laboratory. The physicists dressed quite casually, wearing jeans and shirts with rolled sleeves. Their style was not fashionable, and they were not concerned with the quality and fit of their clothes. Engineers and senior technicians had two different styles: either a collegiate mode or a studiously informal appearance. The collegiate manner involved wearing khakis, button-down Oxford shirts, and crew-neck sweaters. The few women scientists dressed in a similar style, and they rarely wore skirts. This suggests the importance of using clothes to signal which group one belongs to, rather than performing modalities with respect to knowledge.

Ryghaug (2003) found that architects used a presumed difference in dress code, between themselves as dressed in a cool and elegant way and engineers with an un-cool appearance, as a way of performing boundary work (Gieryn 1999). This boundary work was not just about the performance of distinction between the two groups. Several of Ryghaug’s informants interpreted the un-cool dress code among engineers as a negative modality with respect to the engineers' knowledge.

Traweek’s and Ryghaug’s observations resonate with Goffman’s (1959) argument about the efforts people undertake to present themselves in different situations in order to be seen or understood within a particular frame of meaning. To convey a certain impression to a public is also possible through the performance, where impression management plays a part (Clark 1995).

In addition, every activity has a back stage and a front stage related to the performance (Goffman 1959). The front stage refers to what is visible, and where an audience will be present. This is the more permanent or fixed part of a performance and it also defines the situation for the audience. The back stage arena refers to the space where preparations, disguises, and important concealments are done, which leads to the performance. The back stage arena can also be used to take refuge and do things that otherwise would be regarded as discrediting. It is a place where the audiences do not have access and where the players can relax from the play. As Hilgartner (2000) underscores, advisory bodies or groups emerge as performers who will engage in impression management, revealing some things but at the same time concealing other elements. Scientists also actively present some things to the audience while hiding other things backstage.

The way one chooses to dress is, as suggested above, also a way to position oneself. The gown that is used in some formal academic settings is a dignified - some might say pompous - way to show that one belongs to an elite group, emphasizing the positional power and authority assigned to the bearer. Positional power is power affected through authority; for example, that proficiency is a product of position (Weber 1971, Foucault 1979). However, Green (2001) and Kaiser et al. (2001) suggest that academics, at least female academics, are hesitant to use clothes that may be interpreted as a display of positional power. The power suit also represents a uniform professionalism, with connotations that are too glossy and hierarchical for academia. Above all, this is because such displays may be interpreted as a negative modality of their knowledge - that their expertise is insufficient unless supported by positional authority. Moreover, such authority is seen as non-dynamic and thus contrary to academic ideals.

When referencing Goffman (1959), Green (2001) and Kaiser et al. (2001) I find that the greatest challenge of dressing is related to the multiplicity of stages on which academics need to act. For example, they lecture, attend meetings, participate in collegial activities in their departments, and meet with funding agencies, companies, journalists, and the public. Kaiser et al. particularly emphasize that it is important to be connected to different audiences. It is an issue of being sufficiently equal but still different. They describe this as a search for constructive authority. A dress code may be a tool that creates distance between the audience and the performer, but one may also build similar relationships by dressing in an isomorphic manner with respect to the audience. Green and Kaiser et al. focused on women in academia as if these issues are gender specific. Perhaps it would be rewarding to broaden the view relating to professions, gender, and image.

On the other hand, Nowotny et al. (2001) argue that expert knowledge is tied to local and social contexts, and that expertise must be understood through the aggregations that bind actors together. These aggregation mechanisms are especially important in a first meeting. Clearly, the way experts dress is an important aspect of such aggregations, but it remains an open question of how this is managed.

Thus far, this paper has discussed two main sets of questions concerning how knowledge workers dress. One is related to the issue of trustworthiness and the potential role of clothes as modalities reflecting expertise and statements about facts. For example, to what extent is the ideal of ascetics important to display in order to become trustworthy? The other is related to the multifaceted performance of knowledge workers and the relationship between diverse front stages and the back stage of everyday work life. In turn, this is above all an issue about the performance of differentiation relative to similarity, about how to be equal but not too equal.

Thus, we shall investigate how knowledge workers account for the way they dress, and how these accounts resonate with our two main sets of questions. Do knowledge workers dress to become positive modalities? Do they choose clothes with a concern for how they are able to relate to their various audiences? Or is dress mainly an issue of personal statement: who am I?

How to discover dress codes?

On the one hand, it is possible to think that every decision regarding dress code and behavior is individual. On the other side, the cultural organization literature emphasizes that dress codes and image creation are a collective affair (Alvesson 1993). I would like to broaden this perspective in this article by using data from five different knowledge intensive businesses. The data was collected from the autumn of 1997 until the summer of 2002. All the companies did consultancy or other knowledge intensive work. Four of them were engaged with software or computer system development (Hermes, Calculus, Artemis and ITcom), while the final one was an applied research institute (IFOS).

Data from Hermes and Artemis was mainly collected through 12 semi-structured interviews, each lasting about one hour. In the three other companies, I did more extensive observations, complemented by semi-structured interviewing. In IFOS and Calculus, group interviews were used to gather information and opinions. These interviews lasted about two hours each, with an average of six participants.

IFOS, the applied research institute, was multidisciplinary. The employees were educated in engineering, science, medicine, and social science, doing research, development and consultancy. Their customers came from industry as well as the public sector. During the observation periods in ITcom and Calculus, I was affiliated with one project in each company. My main focus was on understanding the meaning that employees ascribed to their everyday activities. I filled my notepad with details from the work surroundings, notes from meetings, discussions and interviews, and everything else I was able to describe.

Table 1 provides an overview of my informants and the ascribed names of those quoted in the paper. Informants from Artemis with the letter A, Hermes have names beginning with the letter H, Calculus with E, ITcom with M, and in IFOS with L.

Table 1. Overview of informants.

Companies	Total no. of interviews:	Cast – in the paper:	
		Name:	Project role:
Artemis	6	Astrid Are	Project manager Project member
Hermes	6	Herman Håkon Helen	Project manager Project member Project member
Calculus	25	Eystein Endre Ernst	Project manager Project member Project member
ITcom	3	Marianne Mathias	Project manager Project member
IFOS	22	Ludvik Leiv	Project member Project member

Suits or jeans?

It is often claimed that the dress code in Norwegian industry is rather informal. This should provide substantial autonomy for knowledge intensive companies to develop their own dress codes. Given that most of the employees of the five companies were trained in engineering or computer science, one would expect that their dress code would be not very outspoken, with many people seemingly dressing with little consideration about their appearance. Informal dressing would then work as a positive modality: See, we are so certain about the quality of our work and our knowledge that we don’t need to dress for credibility.

However, the companies studied displayed a substantial variation and more complexity in how employees accounted for their way of dressing. To begin with, one company – Hermes – stood out as having a dress code that more or less demanded the use of suit and tie. At the other end, Calculus displayed a dress code with jeans and T-shirts as the dominant mode of clothing. The other three, Artemis, ITcom and IFOS, could be characterized as hybrids, with a more complex dress code. Why this variation? Does it have any bearing on the production of knowledge in the five companies?

The most striking characteristic of Hermes was, as indicated, that the “suit frequency” was very high. It was an international consultancy firm, providing centralized training in the use of their project method for new employees. When Håkon, an experienced consultant, described the work culture in Hermes he underscored:

> It is a very young working environment, relatively inexperienced, with many ambitious people. This will characterize the culture also. There are many social gatherings going on, trips, and activities.

Their focus on social activities is typical for organizations that have many young employees, where the company sponsors many of their social activities. Hermes was an international company, but the informants emphasized that their method and mentality were adjusted to the Norwegian context:

> We are adjusted to a Norwegian mentality, for example – it is very easy to talk to anyone. We are a hierarchical organization, but when it comes to exchanging information, who to talk with, and how these things work, then it are obvious that we are not hierarchical. (Herman)

When describing their company it was important for them to state that they were not a hierarchical organization and had a flatter organization structure than other international divisions of Hermes. Helen claimed of their image:

> We have perhaps a Yuppie image. However, when the clients find out who we are and see that we are individuals, then they see us differently. There is not that many that uses double-breasted suits and a tie in this organization.

A yuppie image will often be connected to high- status work conducted by young, well-educated persons. Helen experienced that in client organizations where the educational level was lower, the clients had started out with the impression that the Hermes consultants were "broilers" and yuppies, dressed very formally in suits. However, Helen explained that once the client had sufficient contact with them, they realized that the consultants were hard working and down to earth people. The yuppie image was not hard to understand since the Hermes consultants' clothing style was quite formal in the Norwegian context. Herman explained how he interpreted the rules of conduct in the company:

> Well, here in the office one is nearly obliged to wear suit and tie. I like to appear without a tie, but there are some funny borders between the different groups. Persons from the technology group are those who are most slovenly dressed. They do not wear a tie at the office. At the client office, the project governs our dress code. If they [the client's employees] dress in jeans, then we can dress in jeans. However, jeans are a little too casual, but if it is the norm on the project, then nobody cares. What is expressed is that one is not allowed to be more poorly dressed then the client.

According to Herman, the various Hermes divisions applied different dressing rules. For example, in the change management group it was normal to wear a suit. However, a suit is not only a suit. In the strategy group, all would wear black suits. Herman further explained that the technology group would use trousers and a shirt without a tie. They could even wear chinos and button-down Oxford shirts.

Could we say that these consultants were trying to supply their image with a positive modality through their appearance? As indicated by the interviewers, they were clearly concerned with how their clients interpreted them and that attire and feeling well were important for their self-confidence. As Latour (1987) points out, a positive modality will strengthen the image of a knowledge proposition, and consultants try to blend in and give a good impression with their appearance as well (Clark 1995). They are suppliers of knowledge, and they say they need the clients to accept them and their message. Through their staging of a professional look, they argue that they add a positive angle to their message and feel able to lend authority and credibility to the message presented.

It is also interesting to note the importance attached by Hermes consultants to wearing clothes similar to their clients. Why did they use the imitation or similarity argument? Perhaps they wanted to more easily blend with their clients, making sure that the clients accepted their presence and reducing social distance. Presumably, it is easier to accept people that look similar to us, and also to accept and trust messages presented in a context of mimesis. Melberg's (1995) interpretation of mimesis is based on repetition, meaning that mimesis can be thought of in two opposing ways: similarity and difference. If the consultants appeared in a way that underlined the similarity to users/clients and acted in accordance to with their behavior, then they could try to diminish the differences between them. However, it was a possibility that this also would expose the differences between them. The consultants were hired to do a job that the client themselves were not able to do. Therefore, one will have an inherent difference in the relationship.

The consultants' appearance in Hermes was regulated, and the clothing culture worked as a control device (Hope 1999). This was strikingly different from the dress code of Calculus, a software company with a strong identity as a provider of advanced technological solutions. Here, the mode of dressing was quite informal. Informal clothing meant wearing jeans, t-shirts, pullovers, sandals, trainers, and shorts during the summer. Only the CEO and some managers wore suits regularly. An example of an unusual clothing experience was a week during my fieldwork when a group from a large US company came to visit. The company was interested in purchasing software from Calculus, which would have meant a very important sale. However, even with many important guests at the office premises, the style of clothing remained informal, although many were slightly more dressed up than usual in khaki trousers and shirts without ties.

Had the software engineers given any thoughts to attire conduct? A lunch conversation between two engineers illustrates. Ernst said:

> You do not wear sandals like the rest of us, but have youth-shoes.

Endre responds:

> One looks more like a tech-head with sandals.

For Endre, it was a sign of nerdy-ness to wear sandals, because most of the software engineers wore slippers or sandals at the office. For him, it was a conscious choice not to wear sandals in order to mark a distance from the nerdy image. This indicates that the software engineers do relate to some kind of dress code, embedded in a kind of a professional codex. In Calculus, they were conscious about the hacker or nerd image often attached to software engineering companies. I asked if they shared this image:

> There are some nerds here. There will always be some in a company dealing with computing; it is not a crisis. The employees are competent, and mostly very nice and friendly. (Endre)

The next question to Endre was if there were people that did not communicate well with others, to which he responded:

> There are some who are not so very good at collaborating with others. This can often be a problem, but I have not met many.

For Endre, a nerd was a person that was not that friendly and did not collaborate very well with others. This description of nerds was quite common (see also Weizenbaum 1976 and Coupland 1995). However, in Calculus it was not a drawback to be seen as having a nerdy interest in computers and programming. Still, quite a few were critical about the construction of important knowledge in Calculus:

> It is quite common to appreciate those who work late, eat pizza, and discuss the newest in Java technology late at night. It is a culture for this. However, some, like me, do not take part in these discussions. Other values or competences are more important to me. For me, it is

> important to have social skills as well as being technically capable. (Eystein)

To discuss and show interest in computing in front of colleagues was interpreted as important. Through teamwork, the software engineers could hold on to their identity, and it was a forum for practicing membership (Green 2001). They could also show affiliation to the group, as Kaiser et al. (2001) observed. Calculus is a company with a high focus on technology. However, as Eystein noted, there were different strengths in technology focus among the software engineers. All the same, the nerdy image was important in the company and was highly valued as a sign of competence. Endre told about this when he explained the difference he had experienced between working in Calculus and a large oil company:

> The projects are much smaller here, meaning I am taking part in many operations and I am more involved with the final delivery. We also have more contact, including informal contact, with the client and user. In my former company, the client was from the oil industry. Therefore, we had to dress in suits with ties.

I continued to ask him about the style in Calculus:

> There is not much use for suits here, and I have never been to a meeting where I needed to wear a suit. I enjoy the informal style. In Calculus, one is supposed to work efficiently to make the best possible program. It is silly if things should be very formal and difficult to handle. However, I do not have experience with project management meetings, where they have to be a bit more formal to ensure that the contract is fulfilled. At the project level, things ought to be as dynamic as possible.

Endre was convinced that wearing a suit would inhibit his ability to write good software. His way of linking creativity to dress codes was quite common, and likewise was the association made between formal attire and hierarchical level. Formal attire would mean attending a power meeting, not a professional exchange. Two other software designers emphasized the connection between creativity and an informal dress code by referring to themselves as “knowledge-artists” and “knowledge- performers”. Being a software engineer was for them a creative process. It was not possible, they argued, to be creative when constrained by a formal suit, wearing a matching suit coat and trousers, including a shirt with a tie and dark shoes.

When we compare Hermes and Calculus, we do not see one company with and one without a dress code. Both companies have such codes, but they are different. The difference in the kind of clothes employees wear is striking, but even more so is the way they perceive the rationale behind the codes. In Hermes, the dress code is described in terms that link clothes to the challenges of communicating with clients and users. Wearing a suit and tie is seen as a way of improving communication by providing seriousness and authority. Clearly, the intention is to use clothing as a positive modality, even if there may be some uncertainty about whether they achieve this effect. Their power- dressing could also be considered as a negative modality by their clients (Kaiser et al. 2001).

In Calculus, the dress code is not thought about so much in terms of communication. Rather, clothes appear as a kind of work tool. The informal style of dressing is argued as necessary to be creative and to do a good job as a programmer or software consultant. Thus, in Calculus, we might argue that there was also a vague hint of the ascetic ideal of scientists absorbed in their creative work (Shapin 1998). However, some tensions also surfaced concerning what clothes signified and how employees wanted to be perceived. While many software engineers displayed a nerdy identity through a particular way of dressing (Weizenbaum 1976, Turkle 1984, Nordli 2003), many also wanted to be seen as different and not as nerdy, but as both technologically and socially proficient. Thus, the dress code was not so standardized. It appeared important to the work culture in Calculus to be able to dress informally in different ways.

Hybrid dressers

A hybrid is a mixture or fusion of different objects, and to use the expression “hybrid dressers” brings into focus the mixture of actions related to dressing. In the previous section, we saw how the consultants in Hermes used a quite formal dress code as a way of communicating with costumers to convince them that knowledge from Hermes was of good quality. Calculus’ software engineers, on the other hand, dressed informally because they saw it as comfortable and making them more creative. Their focus was on internal conditions for producing good software, in contrast to the more external focus of the consultants in Hermes. What kind of hybrids between these two styles of thinking about dress codes did I observe in the three other companies?

I shall start with Artemis, a middle-sized computer system development company with Norwegian owners. Astrid stated that in Artemis, she had noticed some differences in dress style between software engineers and consultants. In the consultancy division, they wore suits a bit more frequently:

> Mostly, one can wear whatever one pleases. However, one has to dress according to the client; therefore we try to adjust to the client.

> Nevertheless, at the office [out of sight of clients] you can wear what you want. Some dress in suits and others in jeans. (Astrid)

To Astrid, it was obvious that the consultants needed to dress similarly to the way client representatives did; in particular, not dressing in a way that could be considered at all offensive. Because the software engineers usually worked at the Artemis office, they would seldom encounter client representatives. The consultants' mode of dressing could also be rather relaxed at their own office since that was more like a back stage area:

> The style? I do not really know what you are thinking of. To wear a tie, or not? It is very flexible here, and there is no pressure to dress in a special way. Some other consultancy companies have rules. It is O.K. here; it is relaxed. (Are)

According to Are, Artemis did not have any particular dress code, or rather, their code allowed for a more informal conduct at their home base. He considered other consulting companies to be different; more controlling and stricter regarding conduct and dress code.

The rather informal style was expressed in the appearance of their offices, which looked rather like a backstage, in Goffman's (1959) terms. The rather untidy project offices could be interpreted as emphasizing their image as computer system development experts, rather than classical professionals like lawyers. Artemis' consultants were not very ascetic in their appearance, but neither were they very concerned about being and staging themselves as professionals through their clothes. Their dress code was mixed, or hybrid with a vague dress code.

However, it would misleading just to characterize their dress code as something in between the codes we observed in Hermes and Calculus. Rather, what we saw at Artemis is that they followed the example of Hermes, dressing with a focus on communication with clients, when they are out of office, so to speak. They dressed more elegantly when they had what we could call front stage appearances, especially when they met with clients. When they worked with their projects backstage, they had a dress code that was more like the one we observed in Calculus.

Thus, the hybrid dress code at Artemis was really a system of two codes: a front stage and a backstage code. Thus, they could be seen to emphasize both the communicative aspect of dressing by using clothes as modalities, and the work environment aspect of dressing more comfortably when designing systems and writing code.

A similar hybrid model was found in ITcom. This computer system design company employed approximately thirty consultants. Those who worked with projects at the "home" office met a relaxed dress code, since clients rarely were present. ITcom presented itself as a consultancy company, but they also pursued an image as being highly technological. Perhaps this made them accept more particular styles of dress, like that of Mathias. He was a consultant with advanced technical skills, working with servers, networks and similar tasks. Mathias resembled a rock band member, wearing black trousers and black t-shirts. However, he was special even in the ITcom context.

An example of what front stage dressing meant was provided during one of the project meetings when Marianne, the project manager, explained to the group:

> Today I am going to The Bank to present our estimate on the project management system. I am telling you this because I want you to know what I am doing, and what project we will try to sell to this client.

That day, she wore a suit and not her normal jeans and t-shirt outfit. The suit had matching jacket and trousers in a light brown tweed material, with a white shirt and brown shoes. This suit had a formal and professional look, perhaps tending toward the power suit style described by Kaiser et al. (2001) as a tool for getting credibility. Green (2001) also emphasized that women academics often felt a need to use clothes in a conscious strategy to display professionalism, often related to their need to be taken seriously in settings dominated by men. When making front stage appearances on the professional scene, the attire may help to underscore authority.

The third of the organizations with a hybrid dress code was the applied research institute IFOS. During their interviews, the researchers emphasized their role as independent and innovative scientists. During a normal workday, the clothing style was quite informal. It was not normal to see anyone in a suit; shirts, pullovers, khaki trousers and jeans were part of the standard outfit.

At IFOS, the dress code appeared to be lax. However, similar to what I observed at Artemis and ITcom, this was different when people made front stage appearances. For example, at conferences and meetings with clients, researchers tended to dress a bit more formally, in nice suit trousers, perhaps a dark two-piece suit with shirt, but without a tie. The senior people in the department tended to dress more often in suits or tweed jackets and shirt. It is possible to characterize the latter outfit as the “dissolved suit”, as Hellesund (2000) does, which makes it helpful as a way to dress elegantly while maintaining a difference with the power suits worn by some consultants and administrators.

Arguably, such maintenance of differences was important to people at IFOS as a way of performing their identity as scientists with greater autonomy than they believed consultants had.

> The person that is recruited [to IFOS] has the quality of being independent. Many people here could have had better-paying jobs in industry or in consultancy, but they value the freedom they have in their work here. We have a great deal of freedom with respect to work tasks and how one plans the workday. You have a big opportunity to develop the projects you are engaged in. (Ludvik)

Informants from IFOS generally presented their situation as being characterized by hard work and much individual initiative, with strong engagement and high performance.

> Regarding our professional work, it is important that we appear as something different compared to the universities or consultancy firms. (Leiv)

Leiv did not want to just be a consultant, because he thought that consultants had more routine- based or repetitive tasks. For the institute and each individual researcher, it was important that they could identify themselves with research activities, as described by Henkel (2000). To live up to the ideal of the academic world was important for the IFOS researchers. They strove to be accepted as scientists, which was also related to their need for credibility in front of their clients and the market. However, it was not necessary to use a suit to add a positive modality through clothing. Rather, it was important to signify that they belonged in the academic field.

Dressing for credibility or comfort?

In the paper, I have discussed three main sets of questions concerning the way knowledge workers dress. One is related to the issue of trustworthiness and the potential role of clothes as modalities of expertise and factual propositions. For example, is it important to display ascetic behavior or authority to become trustworthy? The second is about the role of clothing in the quality of the working life of knowledge workers and the potential relationship between informal dress codes and creativity. The third is related to the multifaceted performance of knowledge workers and the relationship between diverse front stages and the backstage in their everyday work lives. What is the meaning of front stage and backstage with respect to dress codes, and how is this reflected in the organizations?

I began by analyzing two very different approaches to dress codes. In Hermes, the code was spoken, and new employees were given an introduction to proper conduct and correct dressing for Hermes' consultants. Here, they defined every stage as a front stage where in employees needed to wear a suit. Every performance was an opportunity to do impression management through appearance, thus adding positive modalities. In this way, Hermes seems to have great concern for the process of communication and how clothing may be part of the management of this process. However, it is unclear whether the aim of being perceived as particularly credible was achieved. Hellesund (2000) claims that the suit has lost its symbolic meaning in the Norwegian setting, but this is not accepted by any of my informants.

Calculus, the company with a strong technological emphasis, was at the other extreme. Their dress code, with the exception of top managers, emphasized the importance of comfort and informality to provide good working conditions and facilitate creativity. They believed so strongly in the quality of their technology that they did not consider it necessary to use clothing to manage the process of communication to achieve credibility. The informants from Calculus believed themselves credible, without any need for ornamentation.

Artemis, ITcom, and IFOS constituted the hybrid category in my study. When dealing with clients or potential clients, considered as their front stage, they dressed more formally and elegantly to achieve the credibility effect considered so important by Hermes. At their backstage, they allowed much more relaxed clothing, probably sharing the belief about the importance of comfort and informality to cater for creativity and productivity that was so strong in Calculus.

It is common to be concerned with how to dress (Hellesund 2000a, Kaiser et al. 2001). Appearance was important as a communication device for most of the consultants and researchers in the study. They believed that clothing was important to the way they were perceived and thus to their credibility. However, we should note that this need to 'dress for credibility' is mainly felt when they want to communicate outside their peer group; for example, with clients. Clothing seems to be important when performing 'public proofs' (Nowotny et al. 2001), but is less so when trying to persuade peers.

Thus, knowledge workers do not primarily dress for credibility. Their dress code is developed in a complex situation where there is an issue of credibility related to non-peer communities, like clients, but at the same time a concern for comfort and creativity related to the actual production of knowledge. Most knowledge intensive companies probably manage this complexity like the hybrid companies in this study do: by differentiating between dressing for front stage performances in front of clients and similar actors and for backstage performances related to peers. However, it is interesting to note that some companies may choose to act as if the entire world is a front stage, while others seem to be allowed to dress for a life in a more protected setting.

Dress codes may, on the other hand, be read as representations of the knowledge production culture. The Hermes code of formal clothing appears in such a context as an expression of a belief that the production of knowledge is not robust, and that positive modalities are always needed to support claims about knowledge. The Calculus code of informality seems to express a more optimistic representation of the production of knowledge as naively credible. The hybrid version, in a sense, makes use of both representations. One dress up for public proofs, while disregarding formal clothing is allowed among peers. Here, credibility may be more dependent on looking different from the future audience of public proofs.

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4

Configuring Designers? Using a Project Management Methodology to Achieve User Participation[8]

Kristin Lofthus Hope and Eva Amdahl

It has long been a truism that user participation is vital to the successful design of computer systems, not just to foster a democratic design (Fuller 2002) but also to provide good solutions (Garrety and Badham 2000, Vadapalli and Mone 2000). User participation seems to improve the ability to supply better systems not only because they are a vital source for information about tasks and procedures, but also because participating users are more likely to claim ownership of the computer system.

However, it has proved difficult to implement user participation in a way that helps software companies achieve more productive user involvement (Howcroft and Wilson 2003, Gallivan and Keil 2003, Hartwick and Barki 2001). This has led to the development of methodologies and procedures that are supposed to facilitate user participation and make it a more efficient element in the design of computer systems. This paper will analyse the use of one such method called 'The Dynamic Systems Development Method' (DSDM). DSDM aims to secure user participation as well as improve other aspects of project management (Fowler 2004). We will examine this claim by analysing its ability to enforce user participation in design. To do so, we have studied DSDM usage in a Norwegian software company that we call Calculus. Valuable

Supposedly, the DSDM framework fosters a high degree of user involvement, particularly by demanding that skilled spokespersons of the client participate in development work (Fowler 2004). However, in the end,

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it is of course the actual practice that counts. This raises a series of empirical questions with respect to the way the DSDM method is employed in projects and how this effects user participation and the interaction between designers and user representatives. However, we would expect designers to be able to enrol users in their concepts and understanding of DSDM (see, e.g., Hatling & Sørensen 1998) DSDM does, in principle, offer user representatives new tools to influence design. Moreover, DSDM could provide a setting that actually facilitates communication between user representatives and the software engineers designing the system.

Many software companies claim that they have superior skills in collaborating with users. Aune, Berker, and Sørensen (2002) underscore that in cases where user input is strong and not limited to only one stage of the process, design seems to be more successful. However, participation may be met with considerable scepticism from designers (Hatling and Sørensen 1998). Consequently, we cannot take at face value claims made about the positive effect of methods on the management of user participation.

This paper will analyze how knowledge engineering teams actually use DSDM as a method to achieve user participation. When making systems, designers deal with many issues, including organizational and social aspects as well as the mapping of tasks and routines. However, the technological focus may often be dominant during development, which implies that non-technical aspects get less attention. For example, Forsythe (2001) observed that engineers designing systems see writing code as the real work. Facilitation of user participation as well as testing was considered less important. Further, Forsythe claims that knowledge engineers do not sufficiently reflect about what knowledge or information may mean. They also spend too little time figuring out what the work of the client is, even though they are supposed to make a workable representation of the tasks and knowledge of the client’s employees.

This may result in what Latour (1999) characterises as a purification process, in which designers categorise and 'clean' the information in purely technological terms to make it suitable for design and programming. This raises the question of whether it is really possible to have user participation as an important and distinctive part of the design process. What strategies may eventually provide successful user participation? Is a dedicated method sufficient?

Understanding user participation

The idea to support democratic workplace development through workers' participation in the design and implementation of technology has long held a strong position in Scandinavia (Pain et al. 1993, Sørensen 1998). It is common in design models to value, acknowledge and integrate user participation in the design process. However, as Hatling and Sørensen (1998) argue, designers often restrict user participation through their control of the design process. Designers claim that users are conservative and blind to their best interests. According to Hatling and Sørensen, software engineers tend to consider themselves as the experts of systems design, as the only ones competent enough to provide the system that the client really needs. Thus, software engineers see fit to use their expert knowledge of how to design a system to control and limit user participation. Thereby, they create a boundary between themselves and the users. Hatling and Sørensen characterise designers as active participants who render users as more passive spectators in design and implementation efforts. In this article, we will challenge this claim.

Important to our argument is the possibility to see user participation as a diverse set of co-constructions performed by software engineers as well as users, avoiding the perception of users or clients as a homogeneous group. This argument is developed from a critique of the idea that designers shape or configure users, which came from Woolgar's (1991) study of usability trials of a new computer. He showed how designers configured the assumed users in the process. An important issue is the effects of such configuration efforts. For example, Norman (1988) emphasizes that users have mental models, which represents a challenge as well as a resource for designers. Akrich (1992) makes users more visible as active participants in technological development. She emphasizes the reciprocal relationship between objects and humans. To avoid technological determinism, she urges us to analyse the negotiations between the designers and users and concludes:

> We cannot be satisfied methodologically with the designers' or users' point of view alone. Instead we have to go back and forth continually between the designer and the user, between the designer's projected users and the real users, between inscribes in the object and the world described by its displacement (Akrich 1992:209).

In contrast to Woolgar's work on the configuration of users, Akrich conceptualises both users and designers as active agents in the development of technology.

Several authors have criticized Woolgar for describing configuration as a one-way process, attributing technological development only to experts in software companies. In recent contributions, Oudshoorn and Pinch (2003) have tried to extend the notion of user configuration to better capture the complexities of designer-user relations. Their work draws on an alternative conception emphasizing that users are also shapers of technologies (see, e.g., Lie and Sørensen 1996, Mackay et al. 2000). Following this observation, Mackay et al. (2000:739) present four ways to extend the understanding of configuration processes:

> 1) We need a symmetrical and more elaborate account of 'configuring'. This begs research on locales and processes of decoding as well as of encoding related to the flow of information and arguments.
>
> 2) Whilst it is clear that designers do configure users, we should note that configuration is not a one-way process: Their own organization and the users also configure the designers.
>
> 3) In these processes, we have to observe that the boundary between designers and users is far from given or fixed. Rather, we should assume that it is fluid, negotiated, constructed, managed, and configured.
>
> 4) Texts are not designed in isolated workshops or designing organizations. We should consider texts as constructed in or through broad actor networks – which extend beyond the confines of the designing organization (Mackay et al. 2000:739).

These suggestions may provide a useful antidote to the widespread tendency to reduce users to mere objects of manipulation.

A problem with the user category is that it tends to designate a rather mixed bag of actors. Often, representatives of end-users in a project are managers or hired professionals, not end-users themselves. According to Casper and Clarke (1998), end-users are those affected downstream by the device or system under development. Users also have different interests, needs, and experiences. Therefore, user participation is not just a two-way relationship between user representatives and designers. The process is more complex, with possibilities for conflicts among the users as well as the designers.

Methods and data

In 2001-2002, we conducted a field study in Calculus, a Norwegian middle-sized software company with approximately 170 employees, most of whom were software engineers. Calculus was process organised, with projects as the main unit of activity. There were five different project areas, each of which had a manager responsible for that particular project portfolio. Calculus' products were mainly custom-made information and knowledge support systems for routine based activities. Their clients were private and public organizations.

As part of our fieldwork, we studied two large system design projects, which we have named NEST and COSMO. The systems were to be custom made for two different public institutions. These clients were large, hierarchical, and bureaucratic, with many decision-making levels and a comprehensive set of administrative regulations directing their complex casework. We followed the project work through the two Calculus teams, participating in internal meetings, client meetings and testing. Thus, we conducted a comparative study of two different teams of software engineers, including their relationship with user representatives from the client companies. The user representatives turned out to be a diverse group. Representatives from different groups of end-users from both client organizations participated in the design process. In addition, in the COSMO project, the client had also hired professional IT-consultants as facilitators or brokers.

We employed an ethnographic approach and focused particularly on everyday work practices in the two teams through a set of week-long observation periods. The first author (Kristin) followed the NEST project most intensively during the spring of 2001, but she returned several times that year to be updated on the team's development work. The second author (Eva) observed the COSMO project during the spring of 2002. She continued to have contact with the design team during the following year.

As mentioned, our prime focus was the project teams, where we interviewed and observed software engineers involved in planning, design, development, testing, and maintenance. However, we also interviewed other employees in Calculus and client representatives, both individually and in groups. In most cases, we used a semi-structured interview guide, and the normal length of the interviews was between one and two hours. The group interviews usually lasted close to two hours. We have transcribed the interviews verbatim. The quotes utilized here have been translated into English. We have tried to retain the informality of expression in these quotes. All informants have been given new names to safeguard anonymity. An overview of our informants is presented in Table 1.

Table 1. Overview of informants in the two projects.

The NEST cast

Name	Role
Espen	Project manager
Einar	Designer
Egil	Designer
Endre	Designer
Oliver	Client's project manager
Ole	Client's project coordinator
Oda	Client's project coordinator

The COSMO cast

Name	Role
Arve	Designer
Are	Designer
Anders	Designer
Andre	Designer
Amalie	Designer
Arne	Project manager
Isak	Client user

Calculus' use of DSDM

The importance of technology to Calculus' employees was evident throughout the company and in the projects. They call themselves 'knowledge engineers', which is common in their area of knowledge management systems. One manager told us that they wanted to account for something, which should give them a distinctive brand in the market. The manager claimed that internationally, the term 'knowledge engineer' is well-known. Another reason to use it was the confidence the term gave. However, not all held the same positive opinion regarding the use of the term. However the manager told us:

> I have seen much of what the engineers have produced with the intension to be communicative with clients. It is a way to talk to the engineering group in that language. You are a sociologist, and thus not the target group. […]. We need to establish confidence, and in this case, the designer has to communicate in a way the recipient likes. We have succeeded in reaching out to our clients with our missions and prove this by getting more contracts, and we are able to hire more people. However, it surprises me that something I thought was a hopeless form of communication rather seems to work.

If we were not the right persons to understand their mission, then who was? Even though their systems' users came from various industries, from the manager's point of view, this does not influence their need to communicate with a focus on their systems' technological attributes.

As mentioned in the introduction, in order to facilitate collaboration between the clients/users and software engineers designing a system, Calculus applied the project-handling tool DSDM. In addition, they utilized an iterative method based on RAP (Rapid Application Development). This implied that during development, software engineers should not be so section oriented. Many tasks were supposed to be open to development at the same time. The iterative style breaks down the project into subsets of functionality (Fowler 2004:20).

Presumably, the framework should take care of both social and technological aspects of computer systems development. The DSDM manual is a framework built and used since the early 1990s by DSDM Consortium members.[9] DSDM is an independent method that claims to recognise that more projects fail because of people issues than due to problems with technology. The focus is on helping people to work efficiently together to achieve business goals. The DSDM method is intended to be tool and technique independent, enabling its employment in any business and technological environment. An important requirement is not to tie the DSDM method to any particular vendor. Above all, DSDM claims to be about improving communication between the various stakeholders and the project team. The approach is said to view people, process, and technology as intertwined components of any business solution. Changes to one component will affect the others. A business change project must include and manage all three aspects, as shown in Figure 1.

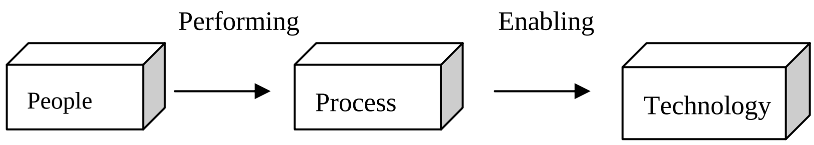

Figure 1. Visualizing the DSDM method.

The DSDM consortium uses the model in Figure 1 to describe the various interdependencies between the involved stakeholders in the DSDM process. The people in the project are performing through the DSDM process, which will therefore enable the development of the technology. The various activities of the DSDM driven project include to plan, to map users' needs, to describe the new system, to select architecture, to design, model, code, and test, to do quality assurance and to provide project management. Stronger user participation in development activities is presumed to be one of the most important prerequisites to achieve a successful DSDM project. This means that active participants should be present the whole project.

DSDM distinguishes between three user roles: the Visionary, the Ambassador, and the Adviser. The Visionary has the visualization of how the system is going to work. The Ambassador is a representative of the

[9] See the web site: http://www.dsdm.com/

entire community of users, with authority to make decisions and to guide the work of developers. The last role is the Adviser – who one may call upon periodically, mainly because s/he is a specialist in a needed field. This was intended to be a cornerstone of Calculus' development work. In any Calculus project, the client should be involved in a specific way to provide necessary resources to the project.

We expected DSDM to function as a checklist so that software engineers might oversee the completion of all development stages. Additionally, we presumed that DSDM would function as a kind of disciplining mechanism in projects to make participants meet the goals within the given time frames. This would include an intrinsic demand of good procedures for user participation, leading to an active co-construction process between users and designers.

From the DSDM perspective, NEST and COSMO were similar. In both projects, the clients had user representatives who were to take part in the development of the respective case handling systems. The software engineers from Calculus were supposed to work with a basis in the DSDM framework in order to develop the system. How did this work?

The NEST project

The NEST client was a governmental directorate. They needed a new system that could help them in their daily work. The system was to be an expert system, which users could utilize to do all necessary tasks during the workday. The NEST project started in 1999, and was initially to be finished by early 2002. However, there were many delays, and Calculus completed the delivery one and a half years behind schedule.

Using DSDM was a part of the agreement between the client and Calculus. During the development process, the software engineers transformed and translated the ways in which the client's employees did their work into an expert system. With an expert system, users may do all their daily tasks through the system, from writing letters to registering a new case. User groups participated in the development work, but they mainly interacted with the software engineers to design and test the different modules of which the program consisted. The users came from all departments in the directorate. Both middle managers and caseworkers participated. Three or four representatives from the client worked together in teams with one or two software engineers to develop the different modules.

It was not an easy task to get hold of all the information needed for making an expert system. What kind of information and knowledge did software engineers require from users? From the interview data, we saw that the software engineers sought very accurate descriptions of the users' work procedures, but also that this information was seen as hard to obtain. This relates to issues usually referred to as tacit and semi-tacit knowledge (Polanyi 1967, Nonaka et al. 1995). An example may be knowledge that was part of the old data system, perhaps as automated information. Another problem was that not all users handle all kinds of cases in the same way. Software engineers tended to have a rather static view of users' knowledge and work procedures, believing that it should be possible to get all necessary information to produce the new system. However, in reality, this could be troublesome:

> Sometimes the client has not been able to specify some of the routines in the handling of cases – some information that was basic for them, but which they did not tell us about. Therefore, in a test phase they ask questions about why this and that are not present in the system. (Einar)

It was common to recognize that the users were important information suppliers. However, it seemed that designers spent little time to figure out users' work (see also Forsythe 2001). Thus, how much influence users had, with respect to the system, was an unclear issue. Even the software engineers told stories of different user group experiences. Egil explained how user group involvement was supposed to function:

> The group consisted of three users and me. The meetings were ideally meant to function in the way that we discussed solutions, little solutions. At the next meeting then, I was going to show them what I had made from their explanations. A kind of repetition of what we had agreed at the previous meeting, and a demonstration of how far we had gotten in the development effort. We should have reconsidered and discussed this development, and then continued to discuss the next solution. Take the development step by step.

This is how Egil said that development should be done, involving a software engineer and a user team according to the DSDM method. One was supposed to have good communication between users and designers and to take the development work forward by discussions, where they should have reconsidered previous development efforts. However, what really happened in this project?

> We have had different technological problems, network problems, and these problems have led to a delay in the pilot project. […] Besides, the users have discovered new needs and therefore we had to make changes. Changes are costly, both to the progress of the system and economically. (Einar)

During the interview, Einar claimed that project delays were due to problems with the computer network and the users' lack of experience with system development. The users had difficulties to adjust to the project in the beginning, and they did not know what their expected contribution was supposed to be. In addition, Einar felt that the users did not spend enough time and were not very committed to the project in the first place.

Another typical explanation of the difficulty with user participation was provided by Endre:

> It is a common problem, not especially for Calculus, to provide too good solutions in collaboration with the users. When users get a very close relationship [to designers], then they obtain more than paid for. Software engineers like to make nice solutions and will then spend more time on development to please the user. As a result, the project can be a bit slow.

Endre maintained that when one is working closely with users, one may be tempted to give them too much. Through cooperation with users, Endre felt that designers were tempted to remake the solution several times to make the users happy. The software engineer may make several improvements of the system's display units, but the cost of this iterative method could be high, the informants claimed. The software engineer ends up in a position where s/he would like to continue the development because it was challenging professionally, but due to costs, s/he was supposed to stop.

However, the users' story was different. As Oliver, the project manager of the client organisation, described:

> Many of the user participants were lawyers with a strong interest in their own field, but with little interest in the implementation of the system. Others had an interest in it, and we tried to recruit those with an interest. Altogether, we have had difficulty in the recruitment of ‘good’ users.

Oliver had a notion of what a good user was - a user with an interest in the system. However, he maintained that their workload was heavy, and the development of the system was not a prioritised task in the client organisation. Oda, one of the project coordinators with the client organisation, told us:

> It was lack of knowledge, where Calculus should have communicated their work method better. In addition, there was a difference between how conscious the project manager and the software engineers from the company (Calculus) were regarding the method. After a year, we had a one day seminar, and it was revealed that the system had some limitations that had not been communicated to us before.

They claimed that users had a difficult time at the beginning of the project, when they did not understand much of the system design method. Neither did the users comprehend what kind of information the developers needed.

> After a while, it became evident that many of the users did not understand the software engineers because they used so many technical terms. […] Users did not understand, and I had to point out to the project manager that he ought to express it once more or explain it thoroughly, but nothing happened. We have repeated this many times; we can call this a communication problem. (Oliver)

Oliver underlined that he thought that the developers spent too little time analysing the client's work routines and the complexity of their casework. In addition, users were not accustomed to the technical terms. Therefore, communication between users and software engineers was difficult. Moreover, in spite of the fact that the software engineers applied an iterative method, users found it difficult to be heard. For example, there had been many discussions about changes. Oliver said that there had been several differences in the interpretation of the method regarding when to report changes, and this problem became visible quite late in the process. Oliver emphasized that in the Calculus team, software engineers and the project manager disagreed about when to report changes. Oliver felt that the disagreements about changes, particularly, led to difficulties for the users and their ability to influence the software development. Ole, one of the client coordinators, said:

> I tried to withdraw myself from the development process when I understood that it was problematic. I lacked motivation.

The problems led to withdrawal from the project, a kind of users' anti-program (Akrich and Latour 1992).

Espen, Calculus' project manager, focused on the software they were going to deliver. It was a piece of technology, even though he also had to consider costs. Defining problems as mainly technological was a way to feel that the challenges were doable (Fujimura 1996). This was particularly important in this case because Calculus had decided to use a new technology in the NEST project, even if clients often prefer older, well-known solutions. Espen explained their choice of technology:

> IT–managers prefer well-known and standardised technological solutions. They want a technology that they have heard about, read about, and can take courses in. Therefore, GemStone [the database technology used in the NEST project] is difficult to sell, but technologically it is a good solution, and it functions. It is very good and very smart. Our choice has to do with our love of technology. Some of us are very technologically interested, and they decide much of the basis for the choices about technology. The database

> technology chosen here is very young and a new line. It is very exiting to work with.

The project manager admitted that the choice of technology could be frustrating because working with a new technology revealed new problems that had to be dealt with at once. Still, Espen was convinced that the team was able to deal with the problems, so at this point in the process he was not worried about the possible risks of operating a new technology in a rather new field.

The design team did not start the development process with an enrolment of the users. In fact, the software engineers did not really use DSDM. Project managers did not see the need to implement the method by actively choreographing (Cussins 1996) activities that needed to be performed. They thought the method would become an integrated part of the development work without much intervention. The software engineers focused on technology and functionality. During the observation period, there was little time to develop the system together with users. Therefore, designers configured the development process and, by implication, users. This was more in accordance with Woolgar (1991) than Mackay et al. (2000).

As a result, the different project groups had problems to communicate with each other because they lacked a common frame of reference. When problems occurred, software engineers tended to see this as caused by lack of commitment among users. Software engineers configured the project by defining what was going to be designed as well as the aspects that were outside the contract or the specifications. The solution was neither optimal nor in accordance with the standards of user involvement in DSDM. A purely technological method dominated the first stage of the development process. Thus, the configuration was mainly one-sided (performed by the designers) and the project teams achieved little in terms of co-construction between users and designers.

The COSMO project

COSMO was considered a large project by Calculus. It involved nearly one hundred persons from the client and the contractors. The project started in 2000 and was delivered to the client in the autumn of 2003. The governmental directorate was to be able to carry out nearly every possible task through the resulting expert system. The technology was based on Frame Solution, Beans, Oracle Web forms, Oracle database, SQL navigator, and PVC tracker.

From the start of the COSMO project, the team focussed on how to utilize DSDM, how to construct a more specific DSDM framework for the project, and paid attention to users and their adaptation of the DSDM method. Another challenge for the Calculus team was how to organize a large project. Therefore, they had constructed a special milestone schedule, which was a calendar where they scheduled the various tasks' finishing dates. The various tasks were named from M0 to M6, where M0 was the kick-off date. Each development team consisted of 3-7 persons (see Figure 2).

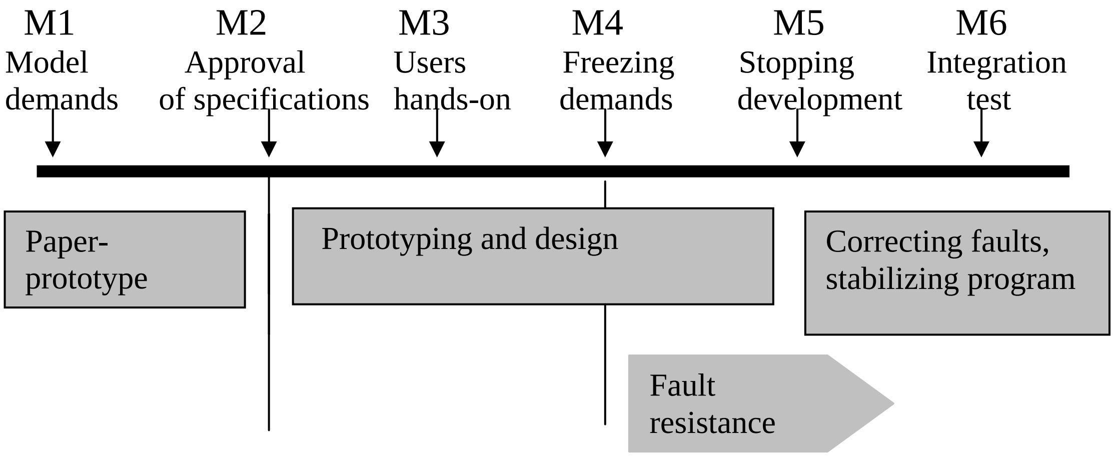

Figure 2. The development process for each module.

The milestone schedule was graphically represented at the project facility. A large piece of paper covered a wall in one corridor, which gave the schedule a strong physical presence for the teams. Perhaps the large poster had a disciplining function as well, because it was a reminder of the time limits of the project. In addition, finishing dates for each team were marked on the poster and were therefore visible to all. The milestone schedule was an attempt to coordinate the various actions in the project. This created a meeting point for all the different users, who saw to the following of the movements.

The first delivery focused on getting a functional technology, including tests of the developed technology. In contrast to the NEST case, the client in COSMO had decided their requested technology in advance. Stage two involved work processes and functionality as well as a more goal-oriented DSDM and user driven development. Functionality characterized the last development stage, but interfaces of the total system were also important. Within each of the different development stages, there were smaller part deliveries. Several teams were responsible for these.

The perception of the stereotypical engineer fits well with the notably tenacious stereotype of the 'nerd' who is the wizard at technology but hopeless at personal relationships (Kleif and Faulkner 2003). During a group interview with people from the COSMO team, we talked about their technological focus to see if it differed from what we observed in the NEST case:

> **Arve**: In each project, we learn a lot, but when it comes to implementation of these experiences in a new project we are not so sophisticated. Starting on a new project, we start from scratch.
>
> **Are**: And we find it pleasurable to discover it once again!
>
> **Arve**: The previous solution was perhaps not an optimal one, so we have to try to do it another way next time.
>
> **Are**: Or we have to select another technological platform than the previous, despite the fact that we had a lot of work with the platform.
>
> **Arve**: That one was not completely object-oriented, so then we had to utilize another one (laughing).
>
> **Interviewer**: Yes, but I wonder, how does the relationship between the new client and the new technology work?
>
> **Are:** We are so technology absorbed. The consequence is that we do not consider the economic aspect of the design.
>
> **Interviewer:** But what happens when something goes wrong or does not function?
>
> **Anders***:* Well, not all of us think that a method is an important thing. Some think that it is alright to make a decent and fancy thing or object. For many the feeling of doing proper programming is important, and in that case, the project management is not so important. A box of cola and a big task – then the evening is set.

This conversation was conducted with much humour. It seems that the opportunity to take part in development processes that utilized the latest technology was considered very exiting. However, for career purposes or to obtain a high status, it was also important to have good technological skills. In addition, it was vital to the software engineers that Calculus had a reputation as a pioneering technology firm. Here, there were no differences between the NEST and the COSMO teams. No doubt, in both cases design was about pleasure and enthusiasm (Kleif and Faulkner 2003).

André stated that software engineers had opportunities to participate in many tasks: meeting clients and defining requirements, 'architectural' outlining of the system, programming, and testing of the system. Overall, Andre felt that in principle he could take part in the whole development process. However, what do they say about the co-operation with their clients? Arne, the project manager, said:

> It is of great importance to prepare the project method for the carrying out of the project, but also for the successfulness regarding time and quality.

By preparation, Arne meant that the management team had to customise or adjust DSDM to the project. In addition, one needed experience to prepare DSDM. For users as well as software engineers, it was easier to understand and use the adjusted method. Both parties had to attach meaning to the method, which had been a demanding process. Arne mentioned time and quality as measures of success, although the project had not managed to meet the time criteria of the first development period. An extensive meeting schedule, too large components, and too few deliveries were Arne's explanation for the delay. The DSDM principle claims the need for small components and frequent deliveries from small teams. After the first period, the project manager spent more time to implement the method and defined its criteria more clearly. Arne highlighted that it had been easier to understand and even accept the method from that point onwards. Moreover, as Arve said:

> This is not a method that we could read about in a distant book, or a method that just somebody knows about. It is, as every milestone in each team, deeply rooted in the method. It is clear that we have managed to implement a common language around how we are working.

The software engineers, as well as their clients and users, developed a very good understanding of DSDM method through courses. Kick-off courses were the users' initial encounter with DSDM. The client's project managers, we were told, had been very competent in the adaptation of DSDM. Throughout the project, new project members were trained in the method and learned how to work in the project. This included the role they were supposed to take in the project and an understanding of what users were supposed to deliver to the project.

Thus, in the COSMO project, they spent a good deal time to understand and to learn how to use the DSDM method, in contrast to the NEST project. The enrolment strategy was utilized with regard to users. In turn, this led to a reciprocal configuration between users and software engineers in the development process. In addition, Arve explained:

> A method is not a method if it is not common among the users. Method is something we have to come to an agreement about how to do. If the tactic from the contractors is to do the method learning for them, this is possible, but you could not call it a method. A method is something which could be checked, verified and falsified from both parties – the contractor and the client.

However, DSDM seemed to demand 'mature' designers. Consequently, it was necessary to spell out the method to make it useable to less experienced software engineers as well: *'Not all of us have the DSDM method in our blood. Some of us need DSDM as a walking frame or as a mentor.*'

In spite of a good enrolment effort, there were some difficulties with the cooperation between the teams. For Amalie, the development work in stage two had been a gratifying experience. Therefore, it was a surprising disappointment that stage three turned out differently. Amalie explained that during this stage, the user group struggled to know what they actually wanted or where they wanted to direct the development:

> The visionary aspects were not present. In addition, since these aspects were missing, one should expect that the coordinator (ambassador) could make decisions or organize to get answers if she did not know the answers herself. […]. The project manager could have told us to report if the role was not represented.

From Amalie's point of view, the project managers could have emphasised role content for both software engineers and users. Instead, the focus was on progress, milestone schedule, and on-time delivery. However, did their use of DSDM really focus on user participation? Amalie said yes, it involved users in the whole process:

> The users are important. The product is a collective responsibility, and the result is collective. The method is also a mutual responsibility, but we did not feel that that the client took responsibility for the method. Although during the delivery of stage two, I did feel that the client appreciated the method in a responsible way. Regrettably, in stage three, the method was not given sufficient priority. During the development in stage three, neither the professional groups [users] nor we [designers] were taken good care of. I used to work with good professional groups, and the new group needed more attention and training. I do not think that the project managers took the problems seriously enough.

According to Amalie's experience, she felt that no one from the client made decisions in accordance to the theoretical demands of DSDM. The manual claims that one of the ambassador's roles is to have authority to make decisions and to guide the designers' work. Thereby, the responsibility for the product is collective. For Amalie's team, the result was that they postponed essential decisions.

Clearly, communication is very important. Users have to understand the technological language, and software engineers have to educate them. Isak, a user representative, underlined:

> Based on my background with an IT education, I could talk to designers. However, the communication could be a challenge in itself.

Isak tried to act as a translator between users and developers. The client had hired Isak and some other IT professionals to help them. Their role was to take care of the client's interests, including the translation of technological vocabulary. It seemed that these professional 'brokers' were important to the client because of their ability to help users achieve a better understanding of the design work and facilitate cooperation with software engineers.

The Calculus project manager emphasized that DSDM had to be shared, and that the method should be understandable to both software engineers and users. This suggests that users and software engineers have to be enrolled into a 'practical DSDM' to be able to configure the development process from both perspectives. This extends both Woolgar's (1991) and Mackay et al.'s (2000) notions of configuration.

In COSMO, the project managers had the responsibility for making the method applicable. Thus, they acted as translators as well as chorographers through the way in which they transformed the method into the milestone schedule. The schedule was an experiment to coordinate the actions in COSMO, and it provided a common meeting place for the participants. It also seemed that the milestone schedule had an interactive disciplining function for the client, users and designers.

Who configures whom?

In this paper, we have analysed the use of DSDM - a method which is supposed to enhance user participation as well as improve other aspects of the management of computer system design projects. For our purposes, we can characterise DSDM as a technology of participation since it is meant as an instrument to get users included in the design of computer systems. In principle, it seems to be an efficient technology, outlining sensible strategies to involve the future users of the system under development. However, in practice, DSDM seems less successful. It should not come as a surprise that it actually takes a lot of effort to make the method work, and even then, success is modest. When we analyse how knowledge engineering teams actually use DSDM to involve users, we observe how participation is rendered problematic due to unresolved difficulties with underlying professional ideologies, temporal and cost constraints, and difficulties in translating between client work practices and knowledge engineering methodologies.

When we analysed the use of DSDM in the NEST and COSMO projects, it looked initially like we could describe one failed and one successful example. However, even in COSMO where a lot of effort was put into making DSDM an operational tool, user participation can hardly be described as well-functioning. Even if the client had hired IT experts to act as brokers to support end-user involvement, there were fundamental problems in making users and designers work together.

Initially, these problems looked as if they were caused by difficulties in making users and software engineers communicate. Clearly, there were challenges related to differences in professional language and methodologies. In COSMO, the IT experts hired by the client worked to solve these problems, but only with limited success. This suggests that the difficulties in achieving good user involvement run deeper.

Previous research has suggested an one-sidedness of user participation, either because designers control or limit participation (Hatling and Sørensen 1998) or because user involvement is by proxy only (Woolgar 1991). We believed this view to be too negative, inspired by the arguments from Akrich (1992) and Mackay et al. (2000). The latter studies suggest a greater balance, where in both parties are engaged in reciprocal configuration. In COSMO, we observed how a 'practical DSDM' was developed and implemented through the interaction of both users and software engineers. Thus, both sides contributed to the configuration of the design process, which extends both Woolgar's (1991) and Mackay et al.'s (2000) concepts. In the NEST case, perhaps, such co-configuration took place even if users had less influence.

On one level, we observe a complex interaction where software engineers and users configure the system design process as well as each other. However, this interaction is regulated by the methodologies and economic constraints of the project. In the end, a strong user involvement is too costly but it is also rendered difficult through design methodologies that lack proper conceptualisation of non-technological issues. Arguably, the software engineers at Calculus seemed not to take communication problems seriously enough. But even in COSMO, where the client had hired professional brokers, communication was difficult. DSDM offers tools to provide an arena where the enrolled users can learn how to communicate with the software engineers. However, DSDM and the technology chosen as the basis of the system act as obligatory passage points throughout the design of the system. Since DSDM only allows for technological communication, this situation makes technology the hegemonic basis of interaction. In turn, this frustrates even empowered users, who experience difficulties in providing a representation of their tasks that is meaningful in the terms of software engineering. Here, we would like to bear in mind that the users in both NEST and COSMO were professionals with college or university degrees.

In principle, for each project there exists a fluid boundary between designers and users, which has to be negotiated, constructed, managed, and, indeed, configured, as Mackay et al. (2000) suggest. However, this relationship, as we observed in Calculus, was not as fluid as Mackay et al. claim. In fact, the relations between software engineers and users were quite fixed from the start in both projects, due to the implicit hegemony of technology as the basis for communication and evaluation. To improve user participation in system design projects, one needs new ways to talk about work as well as computer systems.

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5

Testing Computer Systems: Code, Customers, or Contracts?[10]

Can I please have some help here? The program does not work. This is perhaps the most common exclamation during the implementation of new software. Why are such cries so common? Perhaps the users of the new system misread the instruction manual. Alternatively, the designers may have misunderstood the needs of the user groups of the system during development. In fact, both scenarios are plausible. In theory, software is supposed to be tested and thus work. In practice, the notion of a workable system is not clear. Designers and users may have different understandings of workability. It is during the different test phases of a new system that it is easiest to discover possible diverging views of designers and users as well as other weaknesses. However, what happens when computer software is tested? Clearly, the technology is put on trial, but testing occurs in a social context as well, and may involve different views of what is to be revealed during testing, and what it means to claim that a particular piece of software is working. Consequently, testing may be quite complex and even create conflicts between different parties involved in software development.

This article analyses such testing complexities by analyzing activities undertaken in a Norwegian software company when it tested the results of months of development work and interaction with users. What are the main concerns underlying these efforts, who participates, and how is the process finalized? The underlying idea is that the test phase is a moment in the design and development of technology that is particularly revealing with respect to designer-user interaction and how this interaction shapes new technologies.

Obviously, testing a system for functionality is not just about checking code. Still, the status and social importance of testing is normally quite low in a system development project. In *Microserfs,* Douglas

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Coupland (1995) provides a quite vivid literary representation of software work. While testing may be consequential, it remains low status. What really counts is to design something new, not to find faults and mistakes. Still, new software has to function.

It is a well-established insight from technology studies that to claim that a given piece of technology works implies many social preconditions related to the context of use (see, e.g. MacKenzie and Wajcman 1985, Pinch and Bijker 1987, Hughes 1987). Of course, the rationale behind testing is to find errors that may have a negative influence. The standard issue rose during system development testing concerns whether the program is usable. The assessment means going through a checklist to see how the initial specifications of the system's performance have been met. It is also a control of the code and development work. As we shall see, testing competes with other tasks, which may be experienced as more important or fun to do.

In Scandinavia, user involvement to support democratic development in the design and implementation of technology has held a strong position over the last 25 years (Pain et al. 1993, Sørensen 1998). Normally, context of use in relation to computer systems means some kind of user participation in the design process. From this perspective, testing is an effort to oversee how users' needs have been catered to. However, this does not simplify the task. Rather, it introduces additional complexity because software developers often want to circumscribe end-users specifications. Developers frequently argue that users are conservative and blind to their best interests. Thus, design becomes an effort to deliver what designers think the client needs, not what the client representatives say they want (Hatling and Sørensen 1998). The situation is made more complex since 'the users' may designate a rather mixed bag of interests, needs, and experiences (Aune, Berker, and Sørensen 2002). In addition, representatives of end-users in a project are often managers or professionals, not end-users themselves. They act as spokespersons for the end-users. The end-users are those affected downstream by the device under development (Casper and Clarke 1998).

When computer scientists design software, they tend to use formal methodologies like dataflow diagrams and entity-relationship models (Berry and Linoff 2000). The starting point in the development is the contract between the client and the developer. The contract is intended to regulate their relationship, including economic and legal aspects. Usually, one begins by specifying the different components of the software. This often leads to the use of structured, so-called waterfall methods, where one specifies and finishes one task before moving on to the next (Fowler 2004).

Within waterfall methodology, testing is an integral part of each development task. When one task is concluded, the testing of that section or milestone is assumed to have been done as well.

There is an alternative, called the iterative development method. This method is not as section oriented, so many tasks may be performed simultaneously (Beck & Fowler 2001, Fowler 2004). Accordingly, it is possible to test the system at different levels at the same time. For example, one may test code at the same time somebody else tests a different module. Still, it is an open issue whether there is a clear difference with respect to testing between the two methodological approaches to systems development.

The paper will explore the performance of testing and the relationship between testing and software development practice more generally. It is based on a field study of a large project called Nest, taking place at Calculus, a mid-sized Norwegian system development company.

Testing – a method to make things work?

Technology testing appears to be a rational, objective procedure that can be done again and again to gain general knowledge about the technology and the way it functions. However, a substantive body of work in the field of technology studies has shown this description to be misleading (MacKenzie and Wajcman 1985, Bijker, Hughes and Pinch 1987, Latour 1987, Bijker and Law 1992). A main point is that technology is always designed and used in a local context. This implies that one needs to examine local variations and take into consideration that the design and use of technology may depend on local context (MacKenzie and Wajcman 1985). Technological artifacts are culturally constructed and interpreted, and different norms and values influence the meaning of an artifact (Pinch and Bijker 1987). The design of the artifact is context-dependent, and by inference, so is testing. Nevertheless, what does that mean? As Pinch (1993:28) defines testing:

> A set of activities is carried out in a circumscribed environment that is designed to produce an outcome that gives us information as to the operation of the technology.

The purpose of testing, according to Pinch, is to find out whether the technology is usable and working according to design specifications. For example, are all necessary components integrated? Thus, the purpose of testing is to watch the performance of the technology under scrutiny, and to control that it is acting according to the area of use (Pinch 1993:27-28).

For Pinch, testing concerns machines. Perhaps testing during system development is different? Testing of a new system will open a window to understand and study the system development process and related activities. In the development process, one may even discover what leads to the testing efforts. Testing invites controversies about how the system is meant to perform. The test in itself is not a problem-solving tool, but a cleaning and clearing tool to find out what is working and what is not. In a way, the testing period is a condensed development act, and a window to understand the different elements of the process.

Pinch (1993, 1992) states, that the huge amount of technological data and results that the engineer produces during testing will be a part of their understanding of the technology. This will also influence the way they understand and use the technology. However, when users take part in the development, they have and produce independent views of what is happening. Hatling and Sørensen (1998) found that user participation shapes the interaction of designers and users. Juhlin (1997:71) claims that if one sees testing as a social practice with varying approaches to understanding tests, then different actors will probably not have the same understanding of the test results. The test procedure will simply take the controversy to another level because the involved actors have different opinions about the test result. Therefore, arguably, user participation will lead to more negotiations among the project participants.

The outcome of software testing is more unpredictable than what is expressed in front of the client or in developer circles. Technology will not speak for itself during testing. Rather, the engineer will act as a trusted spokesperson. Juhlin (1997) argues that the engineer or designer has the opportunity to establish statements as facts about how the technology is performing. In intermediate testing phases, engineers may conclude about the functionality of the software. The question is if the software should be accepted or not? Accepting the test calls for a social agreement among the participants.

The test data often represents a final check on whether developers' beliefs about reality conform to the physical world at hand. Perhaps the final check brings forward problems that should have been revealed at an earlier stage, or it may suggest the need to adjust users' expectations, or both. A test may test the user as well as the equipment (Pinch 1993). Another way to see the relationship between the user and the technology is Woolgar's (1991) well-known metaphor of the 'machine as text'. Woolgar's point is that there is a process occurring between the machine/text and the user/reader. One has to read the text in a correct manner to be able to understand the text's instruction and warnings. Like

Pinch, Woolgar claims that the user's character and capacity are structured and defined in relation to the machine. When configuring the user, the developers of the system are, in Woolgar's term, contributing to a definition of the reader of their text. Therefore, the designers will prepare parameters for readers' possible actions as a struggle to configure the user by defining, enabling, and constraining user's possibilities.

MacKenzie (1989:413) claims that one can challenge every test as well as every experiment. There are different criteria that define whether a test is successful, and what the correct result of the test is. If the test does not contain these criteria, then the participants will not be able to evaluate competence. MacKenzie speaks of a ‘tester’s regress’ that may be compared to Collins' (1985) concept of ‘experimenter’s regress’. MacKenzie claims that evaluation about similarities is as important in technology testing as in science. The issue of tester's regress refers to the test situation and its correspondence to similar tests or situations.

If a test’s results are not controversial or according to expectations, there will be few protests. Juhlin (1997) maintains that testers of software must decide how they are going to understand the software specifications in relation to MacKenzie's testers' regress. The process that will lead to agreement about the outcome of the testing should be understood as being shaped by the social relations of the development project.

The main insights from previous research on testing mainly emphasize the role of context and the way this makes the evaluation of tests relative and dynamic regarding the situation in which testing is performed. In turn, this means that test efforts perform work on future users and function in a way that may be seen as a configuration of the technology-user relationship. Thus, we should expect software testing to be a mix of technical trials related to software functionality and social efforts to define and redefine users' needs and capacities.

Testing experience - introduction to Calculus

During 2001, I conducted the field study in a middle-sized, Norwegian software company, here called Calculus. At that point in time, they had approximately 170 employees. Most of them worked as software specialists or ICT-consultants. The company was described to me as process organized, which meant that tasks were structured as projects. Calculus emphasized that its core expertise was knowledge management systems, knowledge technology, and information technology. Their products were mainly custom-made information and knowledge support systems for routine based activities of organizations in the private and public sectors.

My focus was on the everyday work practices in one development project, which I have chosen to call Nest. I used a modified ethnographic approach, where the goal is to obtain a thorough understanding of the environment one is studying (Van Maanen 1988). The various techniques used were observation, interviewing, and participation (Smith 2001:220).

I took part in the project work of Nest, and my goal was to understand the meaning that workers ascribed to their everyday activities. Particularly, I followed the project work of the different design teams, participating in internal meetings, system testing, client meetings, and lunches. The focus during the observation periods in Calculus was to fill the notepad with details about the work surroundings, notes from meetings, discussions, and everything else I was able to describe. It was a complex field experience when trying to cover the ten consultants working with Nest, but interviews with the consultants helped the understanding of the situation. I conducted the interviews mostly on a one- to- one basis, talking to nine of the ten project members. The interviewed and observed software engineers were involved in planning, design, development, testing, and maintenance of the system. Interviews lasted from 45 minutes to two hours in length, and were conducted one-to-one in the participant’s office or in a meeting room. The interviews were taped and thereafter transcribed verbatim. I was able to join the group for four different weeks during the spring of 2001, and I had meetings and interviews with different participants during the summer and autumn of the same year. Altogether, I followed the team of mainly 10 persons for one and a half years. Some of the team members left the project, but others replaced them. I also took part in some test days and in meetings with users, and was able to interview two coordinators of the client and the client project leader. I have given Calculus’ project members names that begin with an E (Espen, Egil, Eva, Einar, Erling, Emil, Ernst, and Eivind). The first letter in the names from the client is O (Oda and Ole).

The time spent with the Nest team was intensive, following their everyday routines and observing their project work. The last meeting with the project team was a team meeting in June 2002, where I presented a preliminary version of this article and we discussed their project and my understanding of their work. During the time in Calculus, I had access to their intranet, where they post organizational, procedural, and technical information. This gave a unique opportunity to investigate the firm’s organizing structures, training and development programs, internal news, HR policies, methods, and knowledge distribution system. Additionally, other personnel in Calculus contributed information and interviews. The work practice of the project members was in focus during data collection and analysis, and I have had an exploratory approach to the field meaning that the study has evolved during the whole period.

To be able to tell this tale about system development testing, I have tried to organize the information from Nest as an understandable structure of incidents during my observation. Of course, this has resulted in a more well-structured narrative then the development work really was. The irony of this procedure is that I have tried to map events onto a kind of linear model of how the testing has been done, knowing that a non-linear model usually provides a more accurate description of design, development and testing. However, for my purposes, it is not the non-linearity of the process that is interesting, but rather the kind of events that occurred.

NEST to develop?

The Nest project was a system development project where the client is a public institution. When I started my field period, the project had been going on for almost a year and was supposed to finish by the end of my observation period in June 2002. Eventually the system took two more years to finish. The client had ordered a data system that could handle their complex case procedures. This kind of information and knowledge support systems for routine based activities is a well-known type of delivery for Calculus. However, they had not used the particular software methodology, called GemStone, in any project where there would be so many contemporary users before.[11] The client organization may briefly be described as a hierarchical and bureaucratic organization with many levels of decision-making and with a great number of legal rules and regulations to follow in the handling of cases. Therefore, the project team set up by Calculus had a huge job to do in order to perform the necessary programming and set up a new data system for the client organization.

The system development team consisted primarily of 10 software engineers from Calculus. During my observation period, there were two women and eight men. The project manager, Erlend, had daily responsibility for the Nest project and contact with the client. The team members had between three to twenty years' experience in system development work. The majority of the team members are ‘programmers’

[11] GemStone is an application server, which can provide transparent caching, clustering an object database capabilities. Within this knowledge management system, one can get access to relevant information according work tasks and project. The system can contain a tight integration with office ancillary system, for example word processing and spreadsheets. For more information see the GemStone company web site: http://www.gemstone.com/

or developers who write code, prepare for system functionality in a way to make the program work. Two persons on the team were architects. When Erlend told me about the different persons involved in the project, he emphasized the important knowledge of the two consultants. They had the overview of the system's architecture and its relationship to the hardware. Presumably, he meant that important knowledge to do such a project is related to the system's architecture and the underlying technology. However, it also tells something about role differentiation among the team members. There were no formalized roles beside project manager, but the team members where labeling themselves as either architect or programmer.

Nest was described to me as a normal system development project. The client had ordered a new data system, and the team was going to develop this by applying an iterative method. This indicates that the users supposedly are taking part in all the different stages of the project, and that one can revise the system under design. The method that the company uses to support development work was called the Dynamic Systems Development Method (DSDM). The first stage in the project was to provide a superior demand specification that described the different stages of the project and outlined the project plan and the system. Calculus and the client draw up the contract after the demand specification was ready.

In their first offer, Calculus presented the technologies they were going to use. They had used the development technology before on similar projects, but they added a new database technology. This was an application server called GemStone. It was a fixed price project, and they negotiated the price at the beginning. Those who had been involved in the demand specification, a two month project, were in charge when the final offer was made and had calculated the estimated time and cost. At a late stage of the project, the responsible manager said that they took a calculated risk when they wanted to try out a new technology in the project. They then saw that the time and cost estimates were too low.

The project team was going to transform the client’s case handling system into a new system. In developing the new system, the developers were transforming and translating the work needs, routines, and the way the client's employees were doing their work. The designers analyzed daily work routines in the client company, among other tasks. In principle, the new system was to provide all the different processes that the users needed to solve their tasks. The system was described a holistic in the sense that all the different steps in the case handling were to be represented in the system. It is through the system one is supposed to be able to carry out the work.

During development, user teams participated. A user team consists of a few user representatives from the client and a developer. Users participated with the developers to design and test the different modules of the program. Many employees of the client were involved at different times in the project. They were important suppliers of information, but one can surely question the role of the users like, as Sørensen (1988) does. He states that users do not have much influence on the 'hands on' development of systems.

The first testing phase

During my first observation period at Calculus, the system had been tested for two weeks. It was the first module in the system that was undergoing the last test before acceptance from the client. Most of the testing was done at Calculus headquarters and located in a so-called test room. The goal was to control the program module and find out if it worked as intended. My observation week was the last week of the three-week acceptance period, and judging from the atmosphere at the project, it had obviously been an uneasy time.

The main problem for developers and user testers during this period was that the module undergoing acceptance testing was not thoroughly developed. There were still things that needed to be constructed, and some system solutions were still being discussed. The development team continued to construct the module and correct errors. Therefore, they launched different versions during this test phase.

However, one needs a stable version to do acceptance testing. A change for later tests was not to try out new version of the program every day, but to have a constant version to test. Then it would be easier for the testers to get a grip on the program. Calculus also had problems with the stability of their computer network. This caused delays for the testers, and the project manager and client coordinator worked to find better routines to make sure that the network lines functioned and that they had a stable version to test. Both users and some designers tested the module in a special test environment, a room with approximately 20 PC's. During the test phase, pressure was high on users. They had a huge workload as usual, and in addition, a high media focus on their casework.[12]

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[12] The client organisation has a high media focus because their case handling has many human consequences.

At the beginning of the project, Calculus did not spend much effort to communicate their system development method to the user representatives. In addition, many of the user representatives had little or no experience with system development work. Since the client organization was hierarchical, the representatives were not familiar with their ability to make decisions about the new software. Normally, it was managers who made the real decisions, Calculus designers told me.

What were the reactions from the user representatives in this situation? They claimed that they did not understand much of the method and what information the developers needed. Oda, one of the project coordinators from the client said:

> It was a difference between how conscious the manager and the developers from Calculus were with respect to the method. They had different opinions about when users could report changes in relation to the system. During the development period, our users were told to report changes at a later point in the development, but it was revealed that the project manager was of a different opinion, and by then it was too late to make any changes.

Although the designers used an iterative method, the users felt that the designers did not listen to them. There were many discussions about changes, and Oda, the project coordinator, felt that the client's user representatives were not well integrated in the project. In addition, there was disagreement between developers and the project manager at Calculus concerning the use of the DSDM method. A year after Nest started, the whole project – users, developers and managers – had a one-day seminar. Here, they discussed the DSDM method in relation to the Nest project. Developers as well as users said that the understanding between them improved after this seminar. Their conclusion was that this seminar should have taken place at an early stage in the development process.

However, there had been problems before the acceptance-testing period. For example, during requirement specification it can be difficult for the users to have a good view of how the program is going to function in the future. Many of the users did not have experience with this kind of development work and lacked understanding of systems development and software engineering. Ole, the other client coordinator, said:

> One does not see things before one starts to use the program. One has not thought about this, and it has been difficult to see these processes under development. Some parts of the program have also been poorly tested.

According to Ole, a reason for some of the weaknesses in testing was that it had taken too long time from the making of the specifications of the program to the actual testing. During this period, the users had forgotten a lot about needs and demands. Some had even changed jobs or tasks. Therefore, it was difficult to call on them to do the functionality or acceptance testing. When they used people who did not take part in the making of the specifications to test functionality, disagreement occurred among different users about how the functionality of the program ought to be. Ole felt that the developers had taken the users' point of view into consideration, but occasionally it had taken some time to get the users to understand the developers' work procedures. His experience was that the developers from Calculus used the argument that the users had specified some of the functionality, and the client had to accept this once they had come as far as acceptance testing. It was too late in the process to make design changes. Therefore, there had to be a change of users as 'users' when they saw the possibilities offered by the program during the project, and thus a change in their understanding and interpretation of the program under construction.

Pinch (1993) says that when one is unfamiliar with systems development, the normal reaction from the user will be to blame herself, and not to question the development process. However, in Nest, when the users felt that acceptance testing was stressful, they blamed the designers for much of the trouble because the system was "in bad shape". Moreover, they had to deal with new versions of the program almost every day in the test period. Oda, the client coordinator, thought that the first acceptance testing was quite frustrating:

> There were too many technical errors with the program. This was frustrating in relation to the final delivery. We used 10 experienced field experts, but they were not able to test properly. During the test period new versions of the program was released, and this made the test more complicated.

Oda blamed Calculus for not being able to conduct the first acceptance test. It was more like a usability test where many technical problems appeared. The client used experienced employees to do the test work, and they got frustrated when they could not do the testing in the way that they were supposed to. In addition, this had consequences for the final delivery of the module and caused a delay of the project. For example, the team spent more time on functionality testing of the module than initially estimated, and the client's project manager commented that he had piles of error logs on his desk to go through.

On occasion during this test, the network did not function, and users could not test the program and felt that they wasted their time. Users claimed extra workloads, since it only meant extra work to take part in the systems development project. During the final phase of the three-week test period, Oda and Espen, the project manager, worked to find better ways of dealing with the various problems for later tests. The outcome was rather small changes; for example, that the developers tested the network before the users appeared. If everything was working, a small team of users came to do the test before a larger team arrived. The designers called the small team the vanguard testers. The vanguards were testers with extensive experience who had taken part in the project for some time. Designers called in the vanguards to check minor changes. In an internal meeting that I attended, the developers said what they meant about the vanguards. Espen put it this way:

> There have been only three testers here today, but they have reported 45 errors. That is great testing. They are doing creative misuse of the program.

The definition of the vanguards was competent testers, and they had a high level of user skills. During testing, the vanguards had proven to the designers that they were competent to act as users and able to handle the failure report system.

Compared to the client's representatives, the designers saw the problems or challenges in the first acceptance-testing period in a different way. ‘Challenge’ is the preferred expression among developers concerning the problems that occurred. When questioned about how much influence the different users had on the construction of the system, the designers gave varied accounts. Egil, one of the designers, told me:

> I had to postpone one part of the development work because I had to do another job in the project, but the time schedule of my component was not prolonged and therefore I just had to make the solutions we (the user team and he) had agreed to at a previous meeting. There was no time to discuss the solution and make sure it was in accordance with the users requests.

He also claimed that this situation came about because the users had great difficulties adjusting to the project in the beginning. The users were not sufficiently aware about their expectations, and they had no previous experience with systems development work. The designers felt that the users did not spend enough time and thus they were not very committed to the project.

On the other hand, there had been serious specifications deficiencies. Supposedly, those who were in charge of a module should have written a very detailed specification report before development work started. Nevertheless, the project team had not done the specification work before they started to work on the first module in Nest. Eva, the head of the department in Calculus, claimed that this was due to professional priorities:

> The people responsible for a module were mostly technically focused and did not care about the administrative task related to software development. The specification reports had not been written and due to this, the modules went above their cost limits. They had only checked what functions the modules should contain, but not time and resource limits for the modules. This lead to a lot of frustration when one had to stop the work with the modules before the user team members felt that they were finished with the development.

Those responsible for the modules in Nest were not aware of the responsibility they had to manage the user teams to achieve a given result. They focused on the technical development of the modules, not on participatory activities. Therefore, the modules went beyond their time and cost limits. Forsythe (2001) found that the technical orientation of the engineers was not talked about much, but it was still the most interesting part for the engineers. Perhaps it was left to silence because one does not need to talk about something that is taken to be obvious to all designers? However, Eva linked her observations to the problematic use of the development method DSDM in Nest. In the review of the project, she said that they had seen different interpretations of the method, which of course should not have happened:

> The designers lacked a proper understanding of the method and were not so conscious about it.

Both developers and users shared the experience that the first module was not in shape for acceptance testing after the test period. The three-week test period had been more like a usability test. Therefore, one may ask if the designers had sufficient knowledge about the client's work procedures and if the user representatives had achieved a sufficient understanding of systems development. Oda, the client project coordinator, meant that there had been trouble in the communication with the designers. Users complained that the designers lacked an understanding of their work procedures, even though Calculus had developed this kind of system before. Another weakness noted by the users was the physical distance between users and designers since they were located in different areas. However, the client also admitted that they could have done things better, for example by allocating more resources to the project.

It is tempting to follow Oda and Eva in their suggestion that many of the problems occurred because the method to be used in the project was not good enough or not properly understood and acted upon. In this context, method is not only a matter of proper procedures. It may also serve a framework and a cognitive coordinator like Werr (1997) and Amdahl (1999) claim. This did not happen in Nest.

Another set of problems mentioned above is related to the diverse and unclear relationships between actors in the project. Mackey et al. (2000) try to describe this by arguing the need to extend Woolgar's (1991) concept of users' configuration. They agree that designers configure users, but at the same time, designers are configured by users and by their own organization. The boundaries between designers and users are not stable, but fluid, negotiated, constructed, managed, and configured, as we also observed above.

In the Nest project, users as well as developers had a rather vague understanding of the method that was supposed to be used. The users were also not familiar with how to do systems development, and the designers had trouble communicating their work procedures. Thus, the reciprocal configuration probably was not very productive for achieving a successful project. In addition, the client coordinator claimed that the project had little help from top management in her company, which resulted in a constant lack of resources.

From such perspectives, testing was primarily an occasion to discover that the project was in trouble. Arguably, it was the project rather than the software that was tested. However, this conclusion would overlook the fact that the project went on, despite the difficulties with the method and the reciprocal configuration. Testing continued along with software improvements. Is there something we have overlooked in the performance of the tests?

Bugs, or not to bug?

Locating errors in the software is a huge part of the different testing phases, and designers spend much time correcting the bugs. Users have a role as inspectors of the work when they test the system. They can approve and test the functionality of the system. In the practical tests, users' influence depends on how they are able to negotiate with the developer about the definition of errors or bugs. The negotiation takes place in the written messages within the test program where the users have categorized the bugs as something that has to be corrected (error type 1), not so serious (error type 2), can be postponed to later versions (error type 3), or not to be acted upon (error type 4).

Developers read and translate the messages. They decide what to do with them, and decide if the users have correctly categorized the error. The client coordinator, Oda, and Espen, the project manager, also discussed the differences in opinions between users and developers. The users' professional knowledge may be in conflict with the system developer's expert knowledge and this has to be resolved.

An example of how the development team managed the rather stressful testing period was the high frequency of meetings during the test period. The project manager took part in many meetings and led them in a rather informal style. During the internal meetings, the designer team discussed mostly technical questions, but also some aspects related to the co-operation with the client. They gave vivid characterizations, both positive and negative, of the participants. Espen, for example, gave advice on how to handle one of the leaders of a user team:

> Olga works up the others in the testing room. Remember to be careful in the communication with her, because otherwise she can make small things big, and she is very expressive.

Espen provided this advice after an intensive test day. It seemed to be a troublesome time for the developers when they had to deal with the users on a daily basis. During their internal meetings, they discussed the failure notices, their technical solutions, and how the co-operation with the users proceeded. These meetings were a way to release some of the pressure, where they freely - without a very formal agenda - could discuss what was on their minds relating to the work.

There were many error reports in addition to network and cooperation problems. Dialogue from a staff meeting illustrates the kind of topics on which the designers focused. Einar and Erling discussed error reports from the users:

> Einar: There are many differences in the error reports. Some are impossible to understand and there are too many of them.
>
> Erling: Yeah, and what can we do about it? Is there a way to limit the amount of reports without spoiling the quality of the reports?
>
> Einar: What do you think about being present at the users test room?
>
> Erling: No, that will take too much time. I have to work with development, and who is going to correct the errors?

Much of the discussion at this meeting was concerned with how developers could cope with the vast amount of error reports and how they were going to educate users to write better reports. The users had been trained to write reports in the error report register, but their mode of writing varied and the designers had difficulties understanding the reports. A particular problem was duplicates of previous reports. In a way, the developers blamed the users for lacking the ability to write reports. Erling was also concerned with his huge development workload, and he did not feel any responsibility to follow up on the users' report writing. The developer team had quite a rough tone among themselves with regard to cooperation with the users. Emil said in an internal meeting: ‘Tomorrow I am going to be a nanny in the test room.’ Emil was going to see that everything would go as planned the day after, and he indicated this in a humorous way. It also tells something about the designer's attitudes and their views about the users. The designer's responsibility was to ensure that everything worked during the system testing and to handle the error logs. They saw the users as valuable informants, but they felt that they needed to be able to control the relationship because software development, including testing, was their field of expert knowledge. An expression of this control was the ability to reject users' error reports:

> Einar: This report is too bad. It is impossible understand what is meant here.
>
> Emil: This is the client's responsibility.
>
> Egil: This has been corrected.

The main reason to reject error reports was that the reports were not understandable or that the developers were not responsible for the error. However, things could be more complicated. During an afternoon meeting regarding the error reports, Ernst, one of the developers, said:

> We have had 56 error reports today, but many are duplicates. We also have a bug where the transactions suddenly are browser dependent. Nobody has seen this bug, just a few selected people.

Ernst doubted that the transaction problem was a real bug. To verify the bug, he asked to have a whole work process sent with the error report if discovered once more. Especially with unwanted information or unthinkable bugs, reports were considered as less reliable.

At internal meetings, the development team may confront the person responsible for the particular software element in a rather direct manner regarding the error logs. For example, the project manager confronted Einar with an error that he was responsible for mending. He had not done anything with it for over a week and answered:

> Yes, I am going to deal with it. Just give me a few more days.

The project manager told me later that Einar had some trouble with the error but had not asked for help. Einar's reaction was to try to sort this out on his own. Other developers reacted differently during such confrontations and asked for help or discussed the problem with others at the meetings. Perhaps relating different behavioral patterns to personality, but it is also possible to relate it to type of error or problem. Some errors were more acceptable, and there was no need to explain why they had arisen. Juhlin

(1997) maintains that there will be some uncertainty regarding sending, resaving and understanding different reports from the participants during a test. Is an error as unproblematic as they say, or is it something that can be quite disturbing? Different types of errors have different meaning. Bugs related to your own code work seem more personal and more difficult for the developer to accept.

Another set of issues emerged when a reported error was not obviously a bug, but rather could be interpreted as a matter of the system's quality. Espen provided an example of this when, at one meeting in which the software developers discussed errors reports, he remarked:

> They (user team) have not reported this previously, and if they want this change they have to pay extra or order it in a later version. One other possibility is a change report.

In fact, this kind of remark was quite common in discussions about error notes during acceptance testing. Clearly, in these circumstances, the software developers felt that the users had made sufficiently thorough reports about how they wanted the program to operate. Users were meant to outline program specifications during the first development effort. Therefore, the designers argued that they could not do much about reported needs for changes after some stage in the acceptance testing. The method used in Nest was supposed to be iterative so that users could take part in the development. However, economic and temporal demands constrained the possibility of letting the process continue to be iterative. At some point, it is argued, one has to assume that users have had sufficient opportunity to clarify their needs and preferences for the system. After this meeting, I observed that the designers began to raise cost issues when the client's representatives wanted to have changes in the program. To begin with, they would say that the change was not within the frames set by the contract and therefore were not part of the agreement. As a result, the client would have to pay extra for the change, either now or in a later version. If the client's representatives insisted that they really needed a different solution in the first version of the program, the project manager could make a so-called change report. However, the client would still have to pay extra to have the change implemented, and this was emphasized to the designers.

In the Nest project, developers and users collaborated in defining 'what the user is like', in Woolgar's (1991) terms. However, one may ask how much real influence users exercised in the definition process. In Woolgar's study, knowledge about 'the user' was distributed within the company - what users were really like. When an iterative method is applied, like in Nest, does that give users improved opportunities to construct 'the user' in their image? To some extent the answer is positive, but with clear modifications. As Mackay et al. (2000) underline, users' ability to be involved in a kind of self-configuration is limited by a number of other configuration activities that go on; for example, to define, enable, constrain, represent, impose and to control users as well as developers. In Nest, we observe the limitation of users' influence particularly clearly in the testing and how test results are interpreted and acted upon. On the one hand, user representatives were allowed to speak as insiders who knew the program and say what was wrong during testing. The users in Nest had observed what did not function and what was wrong according to their own professional standards and their experience from case application handling. On the other hand, it was the designers who were allowed to interpret the test reports, to differentiate between 'real errors' and 'new demands', and to decide what to do.

The second test phase

Technology appears as manageable to designers because they feel they can master the object. However, they may not always be in control. Juhlin (1997) says that technology will not speak for itself during testing; rather the engineers act as trusted spokespersons on behalf of the technology. Does that mean that user representatives participating in such a project are limited to only being spokespersons for other users, as suggested in the previous section?

During a Nest spring testing period in March 2001, the Nest design team did an internal usability test in which a new version of the program was tested. They then discovered a problem with a transaction period that was too long. This long transaction problem occurred when several people worked on the same process at the same server, and each operation took too long to finish. The server could not handle so many processes at the same time.

As previously mentioned, the design team used a new technology called GemStone, and the application server had never dealt with so many contemporary users before. The design team had some indications of the problem previously, but it surfaced on that day in March 2001. Throughout the following week, the architects worked with the problem, but at the end of the week, they still had not found a good solution. The project manager and the two architects together with one other technical consultant from Calculus had a meeting the following Friday and agreed to try a new solution. At the afternoon meeting of the design team the same day, the discussion continued and the two architects presented their solution to the rest of the team.

> Egil: This is a basic problem when we apply this client-server technology that is not made for this use, but just smack a frame solution on top of it. This is a basic problem when we employ the program language that we use.
>
> Espen: Do not tell this to the client now. Do you Eivind (architect) feel that this will work?
>
> Eivind: If I am able to do what we have agreed on.
>
> Erling: This is a problem with the definition of the project. We did not have sufficient knowledge about transactions when we started.
>
> Eivind: I did not have the experience with these patterns. Our firm has never done such large projects on this server platform before.
>
> Espen: We have found this out little by little. Have we over-estimated Gemstone, or have we used it in a wrong way?
>
> Erling: We should have calculated in some more risks.

The discussion continued, and Espen fetched the contract book to look at what they had agreed to deliver to the client. He found that in the contract, they had agreed to a limit of one thousand users simultaneously. He said he had to check the contract to see how big the problem with many simultaneous users was. However, the team concluded that they had a huge problem, and that until they had a plan about how to solve it, they had to keep the discussion within the development team.

It is interesting to note that in the final instance, the project manager turns to the contract as the basis upon which to assess the seriousness of the problem. It is on this legal basis that a technical problem in a sense becomes a real problem, something that had to be solved.

Espen continued to have technological discussions with the design team during the spring. Together with some of the team members, he carried out some research and was also in contact with database program developers in the US. This took a lot of resources, and the team eventually spent one and a half years more than agreed in the contract to sort out this and some other problems. Calculus had to prolong the project at their own cost, and the team worked hard to try to achieve the contract goals. In the end, Espen expressed his doubts regarding technical choices that they hade made; in particular, he was not quite confident in the client-server technology. Regarding the long transaction problem, Espen made the following reflections:

> It was a problem to me. This was typically something one has to experience as project manager. One is at one point annoyed with those who have written the contract, because they were too ambitious. With those specifications that the contract refers to, it will

> often be ambitious. We will find a solution during the autumn; it is frustrating, but one has to deal with it.

Espen was convinced that with enough resources the project team would work out the problem. He is able to deal with technological problems, and for him and the rest of the team the long transaction problem is only a technological challenge. Technological problems are manageable. It may take time to work out a solution, but with sufficient resources and good people, one will find an answer in the end. When they could purify the problem to be only about technology, then it became manageable. Espen held the contract and the team that wrote the contract responsible for the delay in finalizing the system.

Eva, head of the process department at Calculus, had the final responsibility for the content of the contract regarding the specifications to which Calculus had agreed. In addition, the client's role was described in the contract. Eva claimed that the client was not aware of their responsibilities and that the representatives did not really know the terms of the contract. At the end of the first year of the project, when they realized that the client did not understand the terms, the client, users and developers participated in a seminar that addressed the development method employed:

> We gathered the development team, the client and the users and had a session where we examined both the terms and limits of the contract. We also talked about changes, what is necessary to write down and what cannot be done.

When a comprehensive problem surfaces, we see how the contract, its content and an understanding of the terms become important. With respect to Nest, the software development team was asked to gather documentation about the cooperation with the users. Eva underlines:

> We have had technical problems, some are our responsibility, but others are within the responsibility of the client. We try to gather as much documentation as possible from meetings and communication by e-mail. We need to gather it in case there will be discussions with the client. It is not so easy to collect the information when one has a lot to do in the project, but we try to focus on it because it is necessary. It is much easier to write a change report if the participants have agreed.

In discussions with the client, Eva highlighted that her starting point had been the initial contract between Calculus and the client. When there were disputes, she tried to present her view of the case:

> I have to listen to the opponent and try to provide a solution and to consider what a new agreement will mean for the rest of the project. One cannot deal with lawyers in the middle of the project.

Although the technological problems in the Nest project were described as "only" technological and something that the development team would deal with, we see that the legal contract has remarkable importance in the process of assessing what went wrong and who was responsible for the problem at hand. This is due to the fact that to the developers, the contract represents a way to argue convincingly when they claim that the client has not done their share of the job; for example, by allocating sufficient resources for the development work. In addition, they use the contract to assess what they agreed to provide and thus as a resource to argue which of the users' demands and suggestions are inside or outside of the agreement.

This produces an interesting strategic situation where the classification of a problem becomes very important. When testing leads to the discovery of a serious problem, developers have two main options. If the problem has to be solved in order to fulfill the contract, the problem is defined as technological. In such cases, the developers will work to find a solution. If the problem is outside the contract, it becomes a legal and economic issue, rather than a technological one. This complicates software development. While it is commonplace to note that software engineers need to have technical as well as people skills, we observe here the need for an additional type of social skill: the ability to make sense of the legal parameters of a software development contract. In relation to the Nest project, Eva put it in the following way:

> We discovered after a while how difficult the contract situation was for us. Or, if the conditions were to be as written in the contract, we discovered how hard the situation would be for us.

These problems have considerable economic consequences for the project and, eventually, even for the company.

Code, customers, or contracts?

The aim of this article was to analyze the complexity inherent in the testing of large computer- based systems and the management of the problems that are discovered during testing. Previous research (MacKenzie 1989, Pinch 1992, 1993, Juhlin 1997) has shown that testing is not only about getting better technology or better software. Testing and the interpretation of test results are negotiated in interactions between users, technology, and software designers, where the outcome depends on the relative power and strategic skills of the involved parties. This means that testing is context-dependent and thus thoroughly local in character. However, when user representatives are heavily involved in testing, this helps to make the system able to be transferred from a development context to a context of use. Of course, a system does not function without extensive testing of its components. But since there are no really universal set of criteria that may be used to assess if something ‘works’ or not, testing may be a complex and even contested activity.

In general, the findings from my study of testing in the Nest project are in accordance with assumptions made from previous STS research. As expected, we have observed how testing is shaped by the context in Calculus and the relationship with the client, as well as how the outcome of the tests have to interpreted by the software developers in order to decide how to act upon the results. In this way, software engineers are empowered to act as spokesperson on behalf of the technology.

We have also observed a complicated relationship between developers and users. While the software engineers at Calculus seemed to have a more positive attitude towards users than was found by Hatling and Sørensen (1998), the relationship is strained and characterized by many complaints. In contrast to the description by Hatling and Sørensen as well as by Pinch, I found that the designers at Calculus differentiated the user teams. Some users were described as competent and even called vanguard testers. From the designers’ point of view, they had a good understanding of the program and test routines.

Still, the well-known perspective of configuration of users (Woolgar 1991) was important to make sense of the way software developers managed user representatives. We saw how the software and those who developed the system did work that constrained, defined and enabled users’ possibilities during development, testing, and use of the system under construction. DSDM, the method used in Nest, was supposed to provide clear procedures for users’ involvement. But the method was not understood by developers or by users. Instead, the role of the user was understood by both users and developers in an ambiguous and ambivalent manner. No doubt, the relationship between users and developers is complex and many-sided, as argued by Juhlin (1997), Pinch (1993), Oudshoorn and Pinch (2003), and Mackey et al. (2000).

In the analysis of testing in Nest, we have seen that what are considered facts discovered by tests are socially constructed. In addition, it was necessary to compare test results to other results (MacKenzie 1989). This tester's regress has even more wide-ranging implications here when testing is a way to learn how to improve or not improve the system under construction. Developers spend much energy redefining the knowledge to be about changes that one can or cannot do something about. We saw that there was a limit to how far the system could be improved, due to temporal and economic limits specified by the contract. In the Nest project, we observed that when a major difficulty appeared during testing, the project manager looked to the contract to see what the terms and specifications really were.

In fact, the contract proved to be a vital part of the development process when a conflict or disagreement surfaced because it defined the limits and terms of the development work. Through the testing of the system, we saw how the limits and terms in the contract were tested as well. In this process, one returns to the contract’s specifications. This regress is not about comparing the results to results from other tests, but rather what could be considered as a test of the contract. This could be called the contract regress, which has implications that go further than MacKenzie's tester's regress. Contract regress is a back-chained process initiated when testers and developers are caught in a discussion where they need to be concerned about temporal, economic, and legal issues, presumably regulated by the contract. The interpretation of test results has to be done from an assessment if the development has been in accordance with the specifications spelled out in the contract between the client and the development company. As we have seen, when there are many faults and error reports, it becomes important for the development team to discuss and define what the system is meant to contain and how it is supposed to perform. What specifications were put down in the contract compared to what have been developed?

Of course, this is a common constraint regulating development efforts in most business settings. However, the point to be made in this article is how contractual matters deeply influence the testing of a system too. Testing procedures open up for negotiations on many levels, and according to Pinch (1993), this includes ideas of what the system is meant to be. During testing, the software is in a state of limbo where the outcome is uncertain. However, this phase is rather short. In the case of the Nest project, we have seen how developers were able pull the last straw in the negotiations and retained the upper hand in how to define the contract and the system under construction. To some extent, this was due to the fact that they had more experience than the client in managing such issues. On the other hand, the problem with the long transaction had to be solved by Calculus, at a considerable cost and with much delay in the final delivery, since the contract specified demands that meant that the problem had to be worked out.

There is a certain irony here concerning software development methodology. Initially, the method to be employed in Nest was claimed to be iterative to allow users ongoing possibilities for improvements. However, the contract regress meant that the external frame of the waterfall development method was reinstalled. With the waterfall method, a software development process is started by doing the system specification. The next step is then to develop the system using the specifications laid down at the beginning. The goal is to finish one task and then proceed to the next. In the Nest project, supposedly employing an iterative method, we saw that the logic of the contract was set into play when testing started. In a way, it was the limits and terms of the contract that were tested, including the initial efforts of providing specifications. Thus, arguably, the thinking underlying the waterfall method has nevertheless colonized the development process. It was the rather simplistic rationalist preconceptions of the specifications in the contract which, in the end, came to provide the real terms for the development efforts. The specifications of the contract represented a strong force that reshaped the effort to make Nest iterative into quasi linear. Calculus started out with the intention to use a new and exiting technology, but ended up in a more conservative fashion. At least with the kind of contract regime used in Nest, one may be creative before signing the contract, but not afterwards.

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Appendix

Appendix 1

Individual interview guide – project member

Background information:

- Short presentation: name, education, a brief occupational history
- What will you describe as characteristics about your carrier, and what areas have you worked with?
- Where will you be 5 years from now? What is important for you?

Projects you work with now:

- What projects are you occupied with now?
- Could you describe your work, and what you do?
- What are your responsibilities?
- What did you do yesterday?
- What are your roles in relationship to the others in the project?
- How are tasks divided between the groups?
- Whom are you working with? In what way do you collaborate with others, could you describe?
- When is it you need to discuss the tasks with others, and whom do you discuss with?
- When discussing challenges in the project, could you describe how you do it?
- Have you had any problems in the project? How have you handled that?
- How have you resolved, or not resolved the problem?
- How does this project differ from other projects?
- How much do you work? Is overtime an issue?

The development and relation to user:

- Tell about how you work when starting up projects, and how this project developed.
- In what way have you collaborated with users and client on this project?
- How have you collaborated and worked with the user groups?
- What do the users contribute with more specific on this project?
- Could you elaborate and tell me how the collaboration with the users has been?

- Who takes the important decisions in the project, or what are the important decisions in your view?
- Do you feel that there is a difference between client and users? If so, has it any consequences for your work?

Expertise – knowledge:

- Could you say something about what is reckoned as a good system engineer / researcher?
- Are you a specialized worker, or more an all-rounder? Please describe your category and interests.
- What is the most common category here?
- What kind of competences is important here, and could you say something about way these are important?
- During project work, is it often you feel that you have to close unfinished work down due to limited time? Any examples?

Your relationship to the company:

- How is it to work at this company?
- To work at "home" (at the company premises) or at the client, what do you do and how do you experience this?
- How do experience to work here compared with other experiences?
- What do you mean, and could you elaborate?

Appendix 2

Project leader interview guide

Background information:

- Short presentation: name, education, a brief occupational history
- What will you describe as characteristics about your carrier, and what areas have you worked with?
- Where will you be 5 years from now? What is important for you?

Project management:

- When and how did you enter the project?
- Could you describe your work, and what you do?
- What are your responsibilities?
- What did you do yesterday?
- Tell about your entering the project manager position.
- You have a complex job, could you elaborate a bit about your tasks and the challenges?
- Would you characterize your involvement with the project as "hands on", or not?
- In addition, what are your main duties?
- How do you share out the duties?
- Would you characterize the project organizing as rather flat? Could you elaborate?
- How do you experience to manage the human resources on the project?

The everyday project experience:

- What has been a success in the project?
- Why?
- How do you react when something does not function on the project?
- What have been troublesome in this project?
- Why became this a problem, and how have you dealt with it?

Users and client:

- How has the cooperation with the client evolved?
- What have you experienced as positive, and why?
- The things that have been more troublesome are? Could you elaborate?

- I have some examples of things that I have perceived as troublesome, what have you done with those?
- How do you handle things that are a conflict?
- Where can you get help to resolve problems?

Expertise – knowledge:

- Could you say something about what is reckoned as a good system engineer / researcher?
- Why are the characteristic given important?
- What kind of competences is important here, and could you say something about way these are important?
- Are you a specialized worker, or more an all-rounder? Please describe your category and interests.
- What is the most common category here?

Your relationship to the company:

- How is it to work at this company?
- To work at "home" (at the company premises) or at the client, what do you do and how do you experience this?
- How do experience to work here compared with other experiences?
- What do you mean, and could you elaborate?

Appendix 3

Interview guide for client interviews

Background information:

- Short presentation: name, education, a brief occupational history
- What will you describe as characteristics about your carrier, and what areas have you worked with?

The Nest project and your involvement:

- What projects are you occupied with now?
- Could you describe your work at the Nest project, and what you do?
- What are your responsibilities?
- What did you do yesterday?
- What are your roles in relationship to the others in the project?
- How are tasks divided between the groups?
- Whom are you working with? In what way do you collaborate with others, could you describe?
- When is it you need to discuss the tasks with others, and whom do you discuss with?
- When discussing challenges in the project, could you describe how you do it?
- Have you had any problems in the project? How have you handled that?
- How have you resolved, or not resolved the problem?
- How does this project differ from other projects?

The development and relation to Calculus:

- Tell about how this project started.
- What is your experience with the development?
- In what way have you collaborated with the system engineers?
- How has this been? Could you please elaborate?
- What are your responsibilities regarding the user groups?
- What do the users contribute with more specific on this project?
- Could you elaborate and tell how the collaboration between the users and system engineers has been?
- Has it been difficult to understand the system engineer's language and method?
- How have you worked in relations to their method?

- Who takes the important decisions in the project, or what are the important decisions in your view?
- Do you feel that there is a difference between client and users view? If so, has it any consequences for your work?
- Could you explain what will be a good program for you? The program under development.
- Are your criteria the same as your organization? For example: delivered on time, money spent, the best possible solutions, user-friendliness and so on.

Could you tell about your planned implementation process for the program?

Appendix 4

Group interview guide

Background information – participants tell about themselves:

- Short presentation: name, education, a brief occupational history
- What will you describe as characteristics about your carrier, and what areas have you worked with?
- Why have you chosen to work at this company?

Relationship to the company:

- Could you briefly talk about what have been the point of departure in establish this company?
- What are special with this division in relation to other divisions?
- How do you experience the atmosphere at your division?
- What is the recruitment strategy here?
- Is there a stable workforce in this company, or do people change jobs often?
- How much do you work? Is overtime an issue?

Projects you work with now - participants tell about themselves:

- What projects are you occupied with now?
- Could you describe your work, and what you do?
- What are your responsibilities?
- What did you do yesterday?
- What are your roles in relationship to the others in the project?
- How are tasks divided between the groups?
- Whom are you working with?

Collaboration (get the group to discuss the various subjects):

- In what way do you collaborate with others, could you describe?
- When is it you need to discuss the tasks with others, and whom do you discuss with?
- When discussing challenges in the project, could you describe how you do it?
- Have you had any problems in the project? How have you handled that?
- How have you resolved, or not resolved the problem?
- How has the collaboration with clients been?
- How do you normally collaborate with clients?

- How does this project differ from other projects?

Expertise – knowledge:

- Could you say something about what is reckoned as a good system engineer / researcher?
- Are you a specialized worker, or more an all-rounder? Please describe your category and interests.
- What is the most common category here?
- What kind of competences is important here, and could you say something about way these are important?
- During project work, is it often you feel that you have to close unfinished work down due to limited time? Any examples?

Methods (the group discusses):

- Is there a superior methodological approach in the company?
- What is a method in this department?
- Do you have several methods?
- Is this related to profession?
- What are the principles for the method?
- How have the methods used been developed?
- Does everybody use a defined method?
- How do you implement and utilizes the methods in the project?
- Is there room to change method during the project?
- Does a method contribute to new perspectives?
- Does the method or methods have limitations?
- Do you develop methods for clients?

Appendix 5

Participants at Calculus:

Project:	Total no. of participants or project members:	Participants:			
		Interview:	Names:	Education:	Project role:
Nest	14	x	Eva	Civil Engineer	Project manager
		x	Espen	Informatics	Project leader
		x	Erling	Civil Engineer	Project member
		x	Egil	Informatics	Project member
		x	Eivind	Civil Engineer	Architecture
		x	Einar	Civil Engineer	Project member
		x	Endre	Civil Engineer	Project member
		x	Evy	Engineer	Project member
		x	Ellen	Civil Engineer	Project member
		x	Erlend	Civil Engineer	New Proj. leader
			Eddy		Project member
			Emil		Architecture
			Ernst		Project member
			Edvin		Project member
Nest Client	4	x	Oliver		Project manager
		x	Oda		Coordinator
		x	Ole		Coordinator
			Olga		Project member
Others from Calculus	5	x	Kristian	Civil Engineer	Manager
		x	Kjell	Civil Engineer	Project manager
		x	Eystein	Informatics	Project manager
		x	Kjartan	Civil Engineer	Project leader
		x	Kim	Civil Engineer	Project leader
Par project	4	Group interview	Espen	Informatics	Project leader
			Karl	Civil Engineer	Project member
			Kurt	Civil Engineer	Project member
			Kato	Civil Engineer	Project member
Cosmo project	3	Group interview	Siri	Civil Engineer	Project member
			Solveig	Civil Engineer	Project member
			Sindre	Engineer	Project member

I have interviewed totally 25 persons at Calculus. In the Nest project, 10 from the project group have been interviewed. Mostly the group consisted of 10 participants, but I have listed all I have met and who took part in the project during my one and a half year observation period. The two group interview's and five of the individual interview's have been conducted together with colleague Eva Amdahl.

Appendix 6

Participants at IFOS:

Department:	Total no. of participants:	Participants:			
		Interview:	Names:	Education:	Project role:
Department A	5	x x x x x	Leander Lauritz Lukas Ludvik Leiv	Civil Engineer Civil Engineer Civil Engineer Civil Engineer Social scientist	Manager Office manager Project leader Project member Project member
Department A	6	Group interview	Lene Leif Live Lennart Lasse Louis	Civil Engineer Social scientist Civil Engineer Civil Engineer Civil Engineer Social scientist	Project member Project leader Project leader Project leader Project member Project leader
Department B	2	x x	Sigvard Svein	Civil Engineer Social scientist	Office manager Project leader
Department B	5	Group interview	Siri Svein Sondre Sveinung Sivert	Civil Engineer Social scientist Social scientist Civil Engineer Civil Engineer	Project leader Project manager Project member Project member Project manager
Department B2	4	x x x x	Susanne Samuel Sol Stein	Social scientist Civil Engineer Civil Engineer Social scientist	Project manager Office manager Project member Project member

I have interviewed totally 22 persons in IFOS, 11 individual interviews and 2 group interviews. The two group interviews and most of the individual interviews have been conducted together with colleague Eva Amdahl.

Appendix 7

Participants at ITcom:

	Total no. of project participants	Participants:			
		Names:	Education:	Project role:	Main project responsibility
ITcom Ark project	8	Marianne Magnus Martin Marius Maria Miriam Matias Malin	Civil Economist Social scientist Engineer Engineer Civil Engineer Engineer Engineer Civil Engineer/ Economist	Project leader Project member Project member Project member Project member Project member Project member Manager	Performance Design Architecture Development Development Testing Technical Manager
ITcom		Trygve Trine	Informatics Civil Engineer	Manager Manager	

The spring of 2002, I followed the Ark project group at ITcom for two months. I have followed up with interviews of the project leader of the Ark project, and two interviews with managers from the head office.