Practices and Cultures of Knowledge Management

Gianni Jacucci [1], Hilda Tellioglu [2], Ina Wagner [2]

[1] University of Trento
Department of Sociology and Social Research
P.zza Venezia 41
I-38100 Trento, Italy
gianni@lii.unitn.it [1]

[2] Institute of Design and Assessment of Technology
Vienna University of Technology
Argentinierstrasse 8/187
A-1040 Vienna, Austria
hilda.tellioglu@tuwien.ac.at
Ina.wagner@tuwien.ac.at

Abstract: In this paper we take a CSCW perspective on knowledge management, looking at it at the level of daily work practice in two different contexts – project management and engineering design work. Special attention is paid to the diversity of artefacts central to knowledge management. Our analysis makes use of fieldwork in two companies. We use the notion of vignettes to illustrate a variety of knowledge management issues of which we want to mainly address three: The existence of different professional cultures and their interpretation schemes and how these influence representational genres, issues of boundary management and what we describe as a fragmentation of the knowledge base, and knowledge management practices as part of cooperative work.

1 Introduction

A number of CSCW researchers from different research traditions have developed a range of frameworks that address knowledge management such as, to take some examples, organisational memory [CB88] [AM90]; common information spaces [SB92] [BB97]; and boundary objects [ST89] [BS99] [LA02].

Work on communities of practice is influential in the discussion of knowledge management [LW91]. A community of practice involves much more than the technical knowledge or skill associated with undertaking some task. Members are involved in a set of relationships over time. For a community of practice to function it needs to generate and appropriate a shared repertoire of ideas, commitments and memories. It also needs to develop various resources such as tools, documents, routines, vocabulary and symbols that in some way carry the accumulated knowledge of the community.

Thompson and Walsham [TW04] discuss the contextual richness from which meaning is generated, using a typology suggested by Blackler [BL95]. He distinguished between embrained, embodied, encultured, embedded, and encoded elements of context. The latter three are of special interest for our purpose. Encultured contextual components are those intersubjectively formed expectations that direct sense making and sense reading. Related concepts are habitus (Bourdieu), frames (Goffmann), scripts or schemata. They all point to the fact that specific professions, (sub)cultures or groupings develop particular ways of reading and understanding that reflect shared contexts and experiences. Contextual components get embedded in organisational roles and hierarchies, formal procedures, routines, technologies, etc. and some of them get encoded in classification schemes, software, template files, etc. The central argument of Thompson and Walsham is that each of these items is relational and that separating it from its "relational arrangement with other embedded contextual factors such as organizational hierarchy, adequate budget, quality control framework, etc., would not have been effective" [TW04, p.740].

In this paper, we take a CSCW perspective on knowledge management, looking at it at the level of daily work practice in two different contexts – project management and engineering design work. Special attention is paid to the diversity of artefacts central to knowledge management. Here we are concerned with aspects of the processes we observed in a manufacturing case, which tell us something about the complexities and challenges: concurrency of processes, need for innovation, actor networks and the need for distributed interactions with suppliers and customers, and so forth.

In the next section we will present our field sites. In section 4 we describe four examples (vignettes) of how knowledge is generated and managed in our cases. We discuss the knowledge management issues in section 5 by differentiating between cultured interpretation schemes, boundaries and fragmentation of knowledge, and knowledge management as part of cooperative work.

2 The Field Sites

Our analysis makes use of fieldwork in two companies – SHC is a large supplier of specialised car components for the automotive industry, VCP a small producer of virtual electronic components. In both companies we spent several days observing ongoing work, combining video observations with field notes and open interviews.

We paid two visits to SHC, one in November 2005 and the second one in March 2006, where we had the opportunity to learn to know a series of activities related to advanced engineering. During our first visit we mainly were able to observe how projects are managed. During our second visit we focussed on the process of innovation as well as interactions with suppliers. We observed co-located and distributed meetings, project meetings as well as design reviews and ongoing work at a series of workplaces in design, testing and purchase.

At VCP, which we visited in November 2005, we had the opportunity to mainly observe ongoing production work (at 7 different workplaces) but we also participated in several meetings – a management meeting, a meeting about marketing issues, a 'crisis' meeting, as well as teleconference or Skype meetings with a customer and with the US based distributor of VCP. Engineers at VCP work in co-located project teams – four to five in one room – and they cooperate with a series of external distributed partners. They are engaged in four different types of activity – they provide design services to other companies, they produce different types of virtual components, and they provide pre-sales and post-sales support for their customers.

In our observations we were interested in the complexity of the work, in people's flexibility in ordering the work process and adapting it situational to the exigencies as they unfold, in their need for getting an overview of the process and status of work. We studied collaboration needs and practices, how different media are used and combined, strategies of aligning work across boundaries, and how cultural differences between professions and/or organisations were dealt with. We in particular looked at the key tools and artefacts in use, at the role of standard descriptions and procedures, and at the use of the physical space for making work visible, sharing etc. and the role of physical objects.

3 Practices of Knowledge Management

From our fieldwork material we selected four examples of how knowledge is generated and managed at SHC and VCP. We call these case descriptions vignettes. They highlight how knowledge and memory are constructed and read, in different contexts and for different purposes.

3.1 Coordinative Artefacts in Project Management

At SHC there are weekly project meetings, sometimes even more, and these are crucial for project management. Meetings help the project manager to assess the progress of the project, to clarify uncertainties, to define responsibilities, to set deadlines, to negotiate objectives and to define new tasks. The main tool for orchestrating all these agenda is what is called issue list (Figure 1). As one of the project managers explains: "As a project manager you are not anyone's boss, you cannot give orders, to-dos are a way of giving indirect orders, setting responsibilities and deadlines".

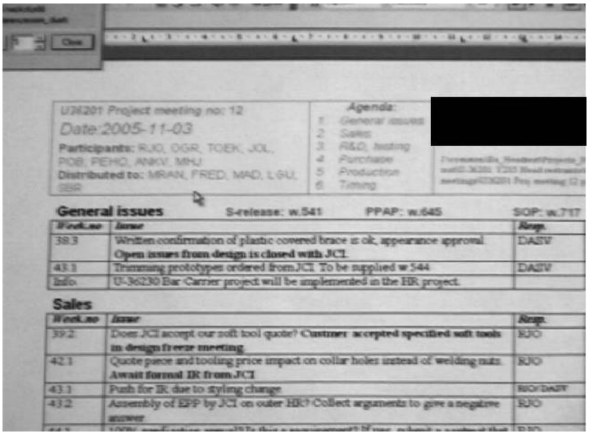

Figure 1: Issue list.

Each issue list as a header with project name, number of meeting, date, list of participants, list of people to whom the list is to be distributed, and agenda. The form of an issue list ensures that issues are addressed in a particular way. The list specifies activities, responsible persons, and deadlines. Issues are identified by the number of week in which they have been addressed and a short text. Starting with general issues, most lists we encountered rather loosely represent a certain order of priority and/or different actors (e.g. R&D, purchase, sales) and/or project stages (e.g. quoting, testing, releasing).

There is a particular meeting dynamics around issue lists. At the beginning of the meeting the project manager opens the issue list. S/he addresses each issue, step by step, asking for status information, eventually changing parts of the task description or the deadline. S/he also may introduce additional issues, specifying action, assigning responsibilities, and fixing deadlines.

Issue lists are the main means for evoking and advancing open issues in a project. There is a voice that is of the directing person, in general the project manager, who leads participants in the meeting through the issue list. It is also the main means for dealing with uncertainties – the issue list allows projecting complex and difficult issues onto separate and linear tasks, expressed in terms of concrete and simple steps.

Although the format has been standardised, there is space for individual practices concerning structure, priorities, highlighting, wording, etc. This means that the objectives connected with an issue list can be personal. Different project managers at SHC have developed their own versions. Moreover, issue lists may contain links to other documents, or have other lists embedded, such as for example the purchase status of tooling. Here the status of tooling is addressed by responsible (in the form of an acronym) and part number.

3.2 Management Tools Designed by Engineers

VCP is a very small and young company with a strong engineering culture. The ways engineers coordinate, communicate and interact, internally and with distributed sites, is extremely effective. They log-on to far-away machines, they use CVS, email, chat, immediate Intranet etc. They exchange daily reports or more formal progress reports as well as some of their issue lists with customers or with their distributor.

At VCP engineers have developed a series of artefacts in support of their own work. An interesting artefact is the email documentation we observed at several workplaces (Figure 2). E2, for example, explains: “There are two ways of communicating technical stuff, one is the technical requirements documentation, the other one is more informal”. He opens a long email, commenting: “A question comes from the customer, I reply – all that goes into the technical requirements. When time is important we use Skype or the phone but especially in the beginning stage I prefer email. … I can keep an archive in my PC, go back to the document – this is a good knowledge base”.

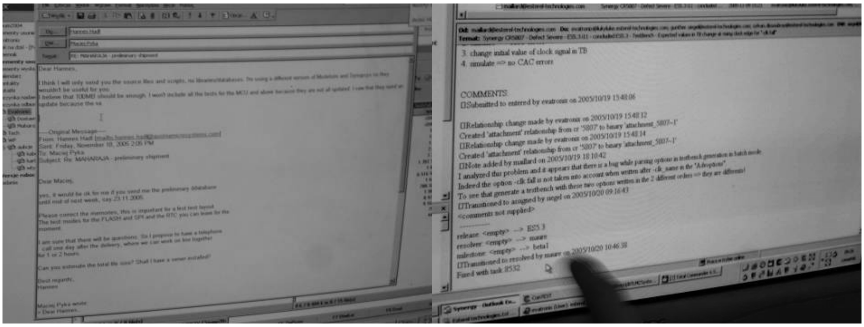

Figure 2: Long emails.

The email documentation supports ongoing work and coordination between customers, the distributor and team members at VCP – it is an asynchronous communication tool. It is a document that grows, capturing the history of a conversation. Its basic structure is questions and answers. Each item is identified by name and date. Different colours are used for questions and answers. The number of ‘>’ indicates how often a problem has crossed borders.

Over time these email documents grow into a personal knowledge base. From the ways they are used in support of ongoing work we can also see that it sometimes is a thinking tool, supporting decision-making. We observed how the engineers go back and forth between email and issues list, carefully formulating their replies.

Engineers at VCP also have issue lists. One example is the list E3 has developed for keeping track of customer requests in post-sales. It lists customer problems with an ID, which is used as an identifier by the people to whom he sends the issue to deal with. It contains also a problem description, a description of the solution as well as a deadline. E3 first developed this list by himself; now it has become part of QMS (the Quality Management System). For this columns have been added about: how the problem was evoked, consequences of the problem, as well as proposals for preventive action. E3 analyses the list several times a year, looking at the number and type of problems, their implications, as well as time spent on solving the problem.

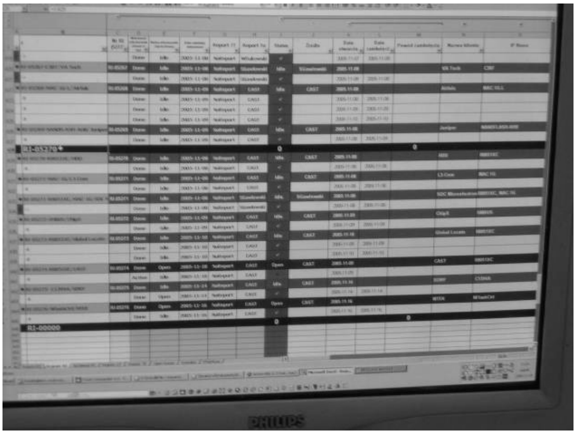

Figure 3: Issue lists used in post sales.

Pre-sales uses a similar, self-developed issue list (Figure 3). Each blue line in the document represents a problem – and then there may be several questions in relation to this problem. There is a problem ID, a description of the problem, the solution, the signature (initials), the customer name and the product name (last two columns). We observed E5 copying problem and solution descriptions from his emails into the MS Excel sheet – the full email text when the problem is complicated. This list is one of the few documents with customer name and product name. It is basically a to-do list with open issues and deadlines. It supports control of pre-sales activities and it includes authorisation procedures – finalised solutions have to be signed off. Moreover, this list provides an interface with the specification document, once the order has been received. E5 talks about the list as their “database”. He uses the list as a repository of problem descriptions that VCP may want to re-use. We also see again how answers to customer requests are composed from multiple sources – email, issue list, simulation results.

3.3 Competing Representational Cultures

In both companies the standard format for documenting technical information are MS Excel files. In these documents information is arranged in the form of lists that follow different organising principles, the items that are listed being parts, materials or tasks. These lists are produced and used by engineers and their project managers.

We witnessed a conflict between the recently established mentor (T) of an innovation project at SHC, himself an engineer, and the project team (among others J and M), which highlights issues of competing representational cultures. T spent some time explaining his idea of creating a shared understanding through a common knowledge repository – to put all documents in one place on the H drive, to create good visualisations of design ideas, to capture all the major decision-relevant points in a growing MS Power Point documentation, which can also be used in discussions with management, and to make use of the company's design handbook (Figure 4). The MS Power Point documentation met a lot of resistance and the following excerpt illustrates some of the issues at stake. T has connected his laptop to the beamer and opens MS Power Point document 'Smart CCU project update':

T: This an old Power Point file - this reflects the status of this project – I use this as a means for updating – there is a tree of where to go – we should do something similar
J: I don't want to make it too complicated – this will need a lot of effort
T: I say after one year of work we will have a file like this
The next slide he shows is a complex table – a comparison of different components (he starts explaining)
J: I did not know we are going to use these types of files – it didn't go into my brain yesterday
T: This is absolutely relevant – this format can be used for a good summary of material, heat up time, alternatives – our management, this is what they want to see – we have to use the same type of tools as they do and start them early – with advantages and disadvantages
J: We need to create Excel files –
M: This is what you do in the end –
T: No, you do it all the time – you have lots of blank slides for all the things that are going in – it's a good tool for all of us to use all the way to present it to management
M: I don't agree. No, I don't agree
J: I don't want the people put their hours on this –

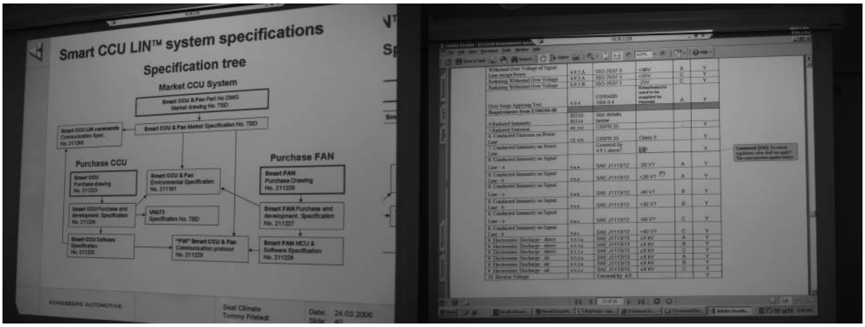

Figure 4: MS Power Point presentation versus list.

The dominant theme in this conversation is participants' resistance to use a documentation format, which is perceived as a management tool and looks like much additional work. The new project mentor expects the engineers to produce representations of their work, which can also be used for arguing their case in discussion with the steering committee. T suggests specific formats for this document, in particular tree structures that allow representing alternative paths, their advantages and disadvantages. He sees it as a growing document, which captures data in ways that back up arguments.

Evidence of competing and/or not compatible representational formats and styles can also be found in how meetings are managed at VCP. The quality manager routinely uses Mind Manager for this purpose. This is a widespread and easy-to-use brainstorming tool. While it very nicely supports the representation of a space of problems, it does not allow to present solutions in a manageable way – like for example the issue lists we saw at SHC. The mind map with which the meeting ended was huge. It contained problem descriptions, intermingled with solutions and specific tasks, some names, and some dates. The quality manager who worked with the tool seemed to moderate the meeting with Mind Manager rather than create a clear work plan. Furthermore, he started from scratch with a blank map. The previous mind map (if there was any) was not displayed and so the connection with the past was not made visible in the meeting room.

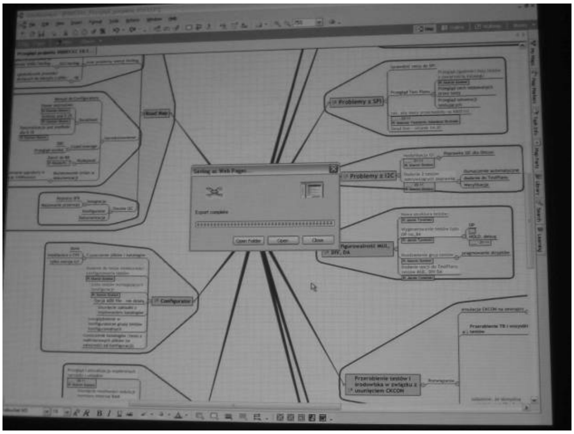

Figure 5: The 'huge mind map'.

3.4 Fragmentation of knowledge: the IMDS system

The IMDS system in use within the automotive industry in compliance with a EU directive is supposed to track chemical ingredients of parts and assemblies across the entire automotive OEM supply chain. The following excerpt describes some of the difficulties involved in working with IMDS at SHC:

A checks her email – the first is a request from their office in D concerning IMDS calculations – a colleague needs details for different heating wires. The email is about not finding the weight for all the wires and has an MS Excel sheet attached.
A has a file on her drive – she talks about having to copy the files all the time and sending them back and forth – she opens a table, noting down numbers on a post-it.
On her list there are two heating wires but the colleague in D looks for more – A sends him the ID for one of the wires and then tries to call the responsible for heating wires.
A explains: "No one is able to give us the right ID for some parts - the problem is that we deliver one part directly to the car producer and one to the seat producer and each has their own part ID - each supplier to LL has different numbers and at LL they don't know which code we have".
A then prints out the list sent by the colleague in D and goes to discuss it with an engineer next to her office. She returns with two new numbers to search for which she has jotted down in pencil – these numbers also don't fit.
A explains: "This is our own list, the one the girl made for us, and it is already a little bit old". A goes through the list manually – they don't have anything on XX.
In another email she receives the data for the part SMART TCU-UN from their supplier. A looks at the data sheet – there are two part numbers, one for the front seat (21153) and one for the rear seat (211618), "when they buy it - when we sell it, we have to use the customer IDs for these parts, e.g. one for AA, one for FF".
Now A needs to communicate the changes of part ID: she fills in a template with her name and the AA ID for the part and sends this to AA to see if they accept this ID – they do not accept.
A calls L who asked for this change, tries another ID – maybe AA has forgotten to approve these numbers – she calls L again who promises to contact AA about this – A makes a note on the print-out of the email message so as to remember.

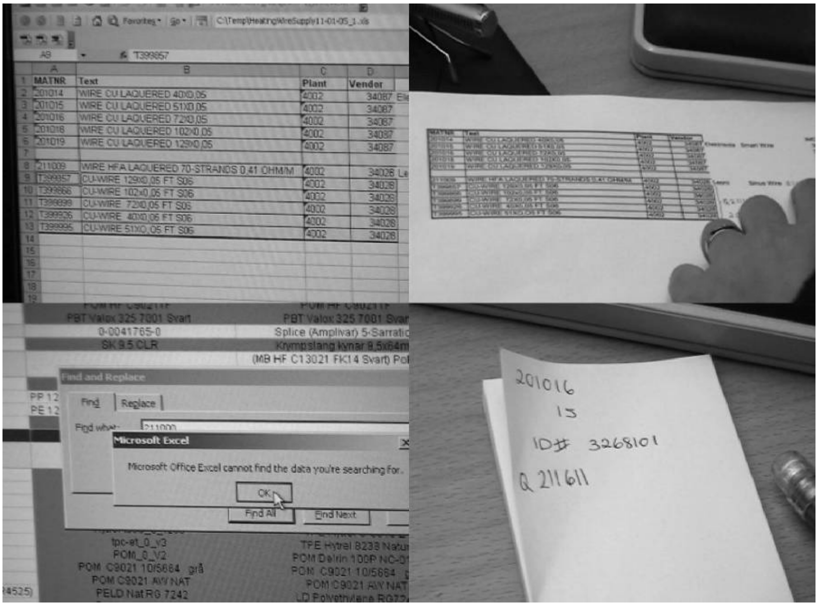

Figure 6: Searching for part IDs.

There are many unresolved issues around the IMDS database: suppliers, in particular small ones, have problems in providing detailed information about their parts – A has problems to retrieve this information. The different stakeholders use different part numbering systems and the mapping problems between these different numbering systems have not been resolved – this affects many workplaces at SHC (among them testing, purchase, and sales). Furthermore, the Excel lists we saw are not continuously updated and again, mapping has not been resolved. The philosophy at the moment seems to be forcing the objective rather than support the process – A switches between her email, different lists, including print-outs of lists, her post-its, phone conversations, printing out lists, carrying them to another office to discuss the problem, and so forth.

4 Discussion

The vignettes illustrate a variety of knowledge management issues of which we want to mainly address three:

- The existence of different professional cultures and their interpretation schemes and how these influence representational genres
- Issues of boundary management and what we describe as a 'fragmentation' of the knowledge base
- Knowledge management practices as part of cooperative work.

4.1 Cultured Interpretation Schemes

Let us first look at the different types of issue lists. They serve different purposes on the one hand, reflect different professional cultures on the other hand.

The issues lists we found at SHC are central in managing projects. Their main feature is that they support the documenting of issues in a normalised way. They provide a template for planning project activities and serve as a workspace in preparation of and during meetings. Issues are raised, defined, and filled into this template cooperatively. They also provide a memory of decisions taken – after a meeting the project manager sends the updated issue list to all project team members – but they do not provide a record of the project management history. The project manager creates a new version for each (weekly) project meeting and only sometimes he goes back to older versions. The lists also ensure accountability – commitments are specified and can be traced, it is made transparent which week they decided on which issue.

The main purpose behind these lists is to document issues and the related decisions for awareness, reference, control, and accountability. This is reflected in their format and representational style. The main organizing principle of the issue list is a timeline, with issues being listed according to the number of the week in which they were raised. The next important principle is ownership, with issues pertaining to R&D, purchase, sales, etc. grouped together. This, amongst other things, allows for crosschecking dependencies between tasks.

We can say that this type of issue lists is management driven. The project manager seeks to establish and document commitments and to ensure coherence between those commitments – that they are fulfilled by those who have been assigned responsibility in a timely way. The script that drives this process is 'neutral' in the sense that it records actions in a generally acknowledged way of managing projects. All larger projects at SHC use what is called the NPI (New Product Introduction) process as a management tool. NPI is document driven and it recommends a particular workflow without enforcing it. That means there is a recommended sequence, which can be varied. Many projects take shortcuts and work within one phase tends to proceed in several loops. At the end of each phase the project manager is supposed to have all the required documents ready, which a coordinating team checks manually and there is a formal signing-off of a stage – each project needs to pass a number of 'gates'.

The engineering management tools we found at VCP are of a different nature. Let us look first at the 'long emails' engineers compose as part of communication with specific customers. They are records of the history of dealing with a particular issue with a particular customer. Different actors may be implicated in these email conversations, internally as well as externally. The engineers have developed a standard format of question and answer, using colour and other markers, inserting detail such as drawings or visualizations of test results. There is no explicit timeline. Instead there is a simple narrative structure, leading the reader through a sequence of questions and answers, with references to work done 'in the background'. This is an entirely self-made knowledge repository, which an engineer may share with co-workers. In fact, these long emails go back and forth within VCP, with the engineer in charge of post- or pre-sales support forwarding questions he cannot answer himself to an expert colleague. This is a very basic and efficient way of managing a task within a small team.

We also saw that items from these 'long emails' may eventually be incorporated into issue lists where they become part of a more shared repository. These issue lists differ from the ones we encountered at SHC. They reflect the concern of an engineering culture with re-use. One of the main advantages of both 'long emails' and pre- or post-sales issue lists is that they allow searching for problems and solutions. The foremost issue at stake is not commitments but the production of coherent data about engineering problems – when were they raised, by whom, what were their implications, how were they solved. A reader will not seek to primarily establish details of a project's trajectory, examining when issues were raised, who was responsible, and when were they expected to deliver. He will look if a specific problem has been raised before, in which context and how it was solved.

Our main observation here is that artefacts – managing tools designed from a business management perspective and those designed from an engineering perspective differ. More precisely, different interpretation schemes and contextual components are embedded in these different types of artefacts and we can decipher these differences through analyzing representational format, style, and practices of use.

Several concepts, some of which we already introduced, are useful in interpreting this observation. The different issue lists are part of different ‘communities of practices’ (Lave and Wenger 1998). Their organizing principles, what they document and in which ways reflects the different concerns and routines of a business management and an engineering community.

Another useful concept is ‘genre’, which Yates and Orlikowski [YW06] use in discussion of PowerPoint presentations in organisations, arguing that “genres powerfully influence the discursive norms of organizational interaction”. Through enactment a genre, such as Power Point presentations, “become regularised and institutionalised templates that shape members’ communicative actions”. They also point at genre innovation – actors producing small variants that eventually evolve into separate genres. We can say that issue lists form a specific genre of reporting and documenting, which has been appropriated by different communities of practice in different ways. We may also consider the ‘long email’ as an example of genre innovation, with engineers evolving an asynchronous communication medium into a ‘repository’ of questions and answers.

Another relevant approach to understanding the differences between representational formats and styles - genres - can be found in Thompson and Walsham’s [TW04] discussion of contextual richness. From this perspective we can look at the different types of lists we examined as having different contextual elements embedded and partially encoded. These elements and relations reflect cultured ways of reading and writing. A project manager designing an issue list from a business management perspective and managing it as part of weekly project meetings does this from another context of knowing than an engineer. While one is arranged around organizational roles, commitments and deadlines, the other is organised around engineering problems and solutions.

4.2 Boundaries and the Fragmentation of Knowledge

In an earlier research [TW99a] [TW99b] on work practices in systems design we identified ‘sources of heterogeneity and multiplicity’, which we understood as being endogenous to design work, trying to understand how these are oriented to within the practicalities of the work. We asked ourselves how people engaged in systems design account for multiple perspectives – of designers with different knowledge, of management, of the multiple future users of their product, etc. – while at the same time ensuring cooperation across boundaries. We found that there are many good reasons for creating boundaries. One of the most prevalent reasons we identified in the cases is the need or desire to protect one’s own perspective on the product to be developed and ways of working. Another reason for creating strong boundaries may be the motivation to survive in a threatening environment. We can also find boundaries when there is a need to balance multiple and not easily compatible voices.

In our fieldwork at SHC and VCP we looked for instantiations of boundaries in some of the key artefacts and the surrounding cooperative practices and came across what we see as mismatches. One example of such mismatches is the IMDS system in use within SHC. Multiple organisational actors and communities of practice are involved in creating, maintaining and using this database – the whole network of car producers and suppliers. Our observation pointed at several misfits, such as the unresolved mapping of different part number systems, the existence of multiple, incomplete and not always updated lists, hence the need to mobilise numerous additional resources for solving small problems of identifying part numbers or completing information in the shared database, including the personal memories of people. We interpret this as an example of a fragmented knowledge base. This fragmentation has several origins: different organisational actors use different parts numbering systems, different responsible actors at the point of data entry build their own files, there are no clear rules and no support for maintenance and process management (comparing, merging, updating, sending out notifications) of the lists.

A quite different example of boundaries is highlighted by the heated argument at SHC about creating MS Power Point documentation alongside the customary technical documentation in form of MS Excel sheets. At play here are the different interpretation schemes of engineers who are used to particular ways of formatting technical knowledge – lists, tables, technical drawings – and those of high-level managers who look for arguments in favour of a particular design proposal. Translating technical data from one format into the other one is considered additional work and not the task of engineering. The engineers in this case want to maintain the boundaries and expect their new mentor to do the translation work for them. He in turn sees both representational genres as connected and expects the different documentations to be aligned continuously. We can see that in some cases there are particular individuals who act as boundary spanners, such as the mentor who is an experienced engineer and knows how to argue with top management about resources and priorities.

We identified more examples of boundaries in our fieldwork at SHC and VCP and what interests us here is the ways in which these become embedded and encoded in representational formats and styles. This may be reflected in small but relevant details, such as people at one of SHC's other sites (in the same country) using different and potentially confusing documentation practices – for example: "They don't keep the front sheet up-to-date with the rest of it – they do it differently – he keeps the original date".

We talk about fragmentation in the sense that not identified or badly managed boundaries, such as the ones we described, may result in a situation where people may find it difficult to bring knowledge together that resides in different documents where it is organised according to different interpretation schemes. Here we recall the distinction made by Thompson and Walsham [TW04] between "'information' being 'data' that has been ordered through the application of knowing activity" and the knowing activity which is grounded in "more systemic contextual assumptions" (p.741). Sharing information, which reflects different cultured knowing activities, requires translation work from one set of interpretation scheme to the other. This is not sufficiently supported by the organisation or by the technologies in use.

4.3 Knowledge Management as Part of Cooperative Work

In earlier work [SW05] we have introduced the notion of coordinative artefacts as crucial for cooperative work in complex settings. The artefacts we discuss in this paper - issue lists, long emails, IMDS - are examples of coordinative artefacts. Their general function is to help managing the complexity of coordinating and integrating cooperative activities, hence also the interdependencies that transcend local interactions. We have described their central features as having a *standardised format*, supporting *practices of identification* and supporting *practices of validation.* What we have added here is that the format of these artefacts, as well as the ways they support cooperative work is not only domain specific but that it reflects different purposes and ultimately different knowing activities.

Ackerman and Halverson [AH00] observed the density and connectedness of artefacts (they use the term memories) used as resources in ongoing work. In our studies of architectural work we identified clusters of coordinative artefacts and practices, arguing that they "are used in conjunction with each other, and together they are instrumental in ensuring and maintaining a workable degree of order in a variety of respects" [SW05]. This is also the case at SHC and VCP where we observed not just single coordinative artefacts but whole clusters of them with multiple references and links. A question here is, how well these references and links are managed. In this respect, the IMDS system is an example and part of a badly managed cluster, its users needing a whole array of additional artefacts and activities, such as personal notes, print-outs, parallel lists, and phone calls to colleagues to be able to navigate.

Finally, we saw that in both companies the knowledge base necessary in support of ongoing work is created and maintained cooperatively. Knowledge ultimately resides in these linked or loosely connected documents, different (not always updated) versions of them, and is something in flux.

5 Conclusions

This papers tries to understand knowledge management issues in project management and engineering design work. It shows that vignettes can be used to describe how knowledge is generated and managed. Vignettes are short scenes that focus on one moment or give one impression about an actor, an idea or a setting. They are very useful to address certain situations or circumstances in work environments. We used them to describe and discuss a CSCW perspective on knowledge management.

Our vignettes showed different issues like the existence of different professional cultures, differences in interpretation schemes, issues and practices of boundary management, the fragmentation of the knowledge base, and knowledge management practices as part of cooperative work (see section 4).

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