15 BALANCING FLEXIBILITY AND COHERENCE: INFORMATION EXCHANGE IN A PAPER MACHINERY PROJECT

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Abstract

The problem of balancing coherence and flexibility in collaborative information system design is approached here with two pairs of concepts. Boundary objects can support communication for perspective taking between communities of practice. Conscripting devices can support communication for perspective making within a community of practice. These theoretical lenses are used to study the uses of the technical specification in paper machine projects. Our study showed that as a boundary object it provided enough flexibility to allow *negotiations, and sufficient local structure, for carrying out work in both communities of practice, the customer and the manufacturer. As a conscription device in the relatively virtual manufacturer project team, however, it proved to be problematic, due to the unidirectional nature of its construction, its diminishing importance in the web of conscripting objects, and its inconvenience as a means for learning. In search for balancing coherence and flexibility, the issues identified seemed to relate to acknowledging the dialectics of perspective making and perspective taking with boundary objects and conscription devices, to the openness and modifiability of these objects, and to the bounded transparency of these processes.*

Keywords: CSCW, document management, coordination, boundary objects, conscription devices, perspective making, perspective taking, community of practice, designing collaborative information systems.

1. Introduction

A key issue in designing collaborative information systems is balancing coherence and flexibility (e.g., Wastell 1993). A coherent information system is capable of being a meaningful, familiar, and useful resource for different communities of practice (Lave and Wenger 1991), and it yields to formal specification to handle its complexity. A flexible information system is able to meet the local, situated activities and interests within a community of practice; it is robust in the face of all these uncertainties (on complexity vs uncertainty, see Mathiassen and Stage 1992). Due to the difficulty of this balancing act, collaborative information systems design also has remained more a craft than a careful application of a theory-based design methodology. The key problem in designing collaborative information systems is thus: if too much coherence is emphasized in the overall design (as many enterprise resource planning, or ERP, efforts do) at the cost of local flexibility, the system may face the problem of becoming an alien, possibly useless resource in actual work practice. If flexibility in the local design is emphasized, the overall design may lose coherence and become useless in its wider collaborative function. Where these meet, there may be considerable tension, for example, between uses of the "under-specified" document databases (local flexibility), and the "overly formalized," detailed entries in enterprise resource planning systems (overall coherence).

For examining this dilemma, we employ two related concept pairs: boundary object and conscription device, and perspective making and perspective taking. Star introduced the *boundary object* to be "an analytic concept of those (scientific) objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them" (Star and Griesemer 1989, p. 393). Henderson has continued Star's work by introducing a specific kind of boundary object, the *conscription device* (Henderson 1991, 1998b), which "both enlists and constrains participation in creating and maintaining the object." The users of a conscription device must engage in inputting its elements and in revising them, if it is to serve its intended function for the users' purposes. These concepts have been used in analyzing why a certain technical solution has not been workable (e.g., Henderson 1991) or would not be workable (e.g., Mambrey and Robinson 1997).

Boland and Tenkasi (1995) have introduced perspective making and perspective taking for discussing how to represent and integrate knowledge across organizational units and boundaries. They refer to communication that strengthens the unique knowledge of a community as *perspective making*, and communication that improves its ability to take the knowledge of other communities into account as *perspective taking*. They tie perspective taking and boundary objects as follows: "Once a visible representation of an individual's knowledge is made available for analysis and communication, it becomes a boundary object and provides a basis for perspective taking" (Boland and Tenkasi 1995, p. 362). We continue from this and suggest a similar link between perspective making and conscription devices: When participants in a community engage in creating and maintaining a conscription device, they engage in perspective making, in communication that strengthens the unique knowledge of their community.

The main focus of our treatise is on establishing the value of these two concept pairs in tackling the coherence-flexibility dilemma in designing computer support for collaboration. We will use these interrelated concept pairs with our case to focus attention on issues that would need to be solved if a certain disorganized document set were to be redesigned to be a part of a collaborative information system, connected to data in ERP and other formalized systems. Our study will not give a detailed design to be implemented, nor detailed methodology rules to be followed, but it could be useful in pointing to a number of focal issues to be solved in the search for balance between coherence and flexibility.

2. Context and Method

Our case company is Valmet (http://www.valmet.com), one of the three largest paper machinery suppliers in the world. Recently, Valmet has restructured its business units to make them more independent from the specialized production units. There are tens of both of these, world-wide. In paper machinery delivery projects, the participating units need to coordinate, however, as "one Valmet," which presents a communication and informing problem. As a company level measure, Valmet has been reengineering its key processes to increase standardization and control throughout the production system, with the goal of cost and time savings. A key dilemma is now to tie together the increased informing and communicating to the increased discipline in production. In terms of information technology, these phenomena are visible in increased information sharing with electronic mail (in use for the past decade) and several thousand specific document databases in Lotus Notes (in use since 1992, with "100% coverage" since 1997), and a comprehensive enterprise resource planning system that is being implemented with Baan and related systems (in stages during the period 1997 to 2001). An aim for these initiatives has been to increase transparency of paper machinery projects and, as a consequence, increase efficiency within the whole of Valmet.

One of the sets of documentation to be overhauled is the *technical specification (TS),* which specifies what kind of a paper machine is to be delivered from Valmet to the customer. While the TS is a set of documents, parts of the information in it—such as product configuration, cost calculation, and pricing—are managed by the ERP systems.

In this study we will give an account of its life cycle, and analyze it with the four concepts presented earlier, to assess how they could assist in solving the coherence vs flexibility dilemma. The practical purposes for our study are to contribute to redesign the structure and use processes of technical specifications, and to inform the choices of technology use.

This study was carried out in the Rautpohja units of Valmet in Jyväskylä, Finland, during 1997. Beforehand, two of us had accumulated considerable background knowledge by working as observing participants (Nandhakumar and Jones 1997; Taylor and Bogdan 1998) for nine months in a separate ISD project in the Project Department. Due to the complexity of paper machinery projects, this time was necessary and valuable for understanding project documentation. Plausibility, credibility, and relevant representation of our interpretations (Altheide and Johnson 1994) were further enhanced by our continued access to Valmet.

All paper machinery projects, and consequently the technical specifications of the paper machines, are different to a degree. Tracing the history and contents of more than one specific TS would have been a sizable effort, beyond the scope of one study. Therefore, the TS of a major current project, Project G, was chosen as the case for our study. The detailed progression of the TS document and its relations to other pertinent documents was traced, in Project G and in general, by interviewing 14 people, with eight representatives of the 50+ member large Project G team. Several descriptions were made (Yin 1989) of the process, of the documents, of communication practices around the TS in general, and of the breakdowns and disturbances encountered (Ngwenyama 1998) with the Project G technical specification. In the following description, each informant is identifiable by the number in parentheses. The interviews and observations made for another study are identified separately.

3. Building a Paper Machine

3.1 Paper Machinery Projects

Building a paper mill with a new paper machine is a major effort: a new, complete paper machine alone can cost from $100 million to $200 million. Due to this, the period from initial sales contacts to signing the contract can often be measured in years. But once the project has started, the start-up can take place in about 18 to 20 months. This is very compact, considering the size of the effort, allowing very little room for mistakes or delays, on either side. Even though there can be parallel and recursive chains of activities, three points of closure—signing the contract, reaching the freezing point for the design and, ultimately, the start-up of the machine—bring the processes together.

In Valmet, at each stage there are several departments and subcontractors involved. Due to the large size of the project, even though the *project manager (PM)* is the key mediator between the customer and Valmet, this boundary is kept rather leaky (Brown and Duguid 1998), with information going back and forth at all levels; that is, information that is "within the contract." This is also true within Valmet and toward the subcontractors. At the same time, the boundaries are impermeable, each Valmet unit guarding its technology and innovations with fervor. Even with this restriction, the amount of detailed information moving constantly between Valmet units and between the customer and Valmet is well beyond the scope of any one person. Therefore, the project is supposed to proceed along predefined paths. Only exceptions and major changes are brought to the attention of the PM.

3.2 The Technical Specification Documentation

The *technical specification (TS)* documentation in large projects can be 500 to 600 pages long, including texts, spreadsheets, and design drawings. It is relatively complex both in terms of structure and uses. During the sales phase, information or sub-bids are collected from the units and subcontractors. During the sales negotiations, there are often five to six cycles of revision before the customer is ready to start comparing the bids. The more knowledgeable the customer is, the more changes are likely to be required. In the actual contract negotiations, those pages of the TS to be included in the contract are initialed by both parties. Therefore the valid pages and information in them can only be confirmed from the paper document. By the time the project begins, the customer has approved of the main points of the technical specification. This does not mean that the technical specification is now approved and final: it will most likely be changed several times during the early stages of the project.

The project is started in a kick-off meeting, where the sales engineer tells how the sales process went and in what kind of spirit the deal was struck. The focal issues are what was sold, what was not sold, and what was sold with an option to add or remove. Dimensioning information are crucial, because they tell what size of machine is sold, how fast, and for what kind of paper with what kind of production. The head designers and their teams then pick out from the technical specification all pertinent information, and compare it to the current design guidelines that spell out the latest machine concept. The PM goes through the differences with the teams, ensuring that everybody understands the idea of the new machine.

During the project, the monthly two-day Project Meetings are the central events between Valmet and the customer, to clarify open issues, to make necessary changes, and to decide on additional investments. These are large meetings, with all the relevant people from both sides attending. Both parties may want to keep the TS as it is, because it is a part of the contract, and any major changes would need to be renegotiated in terms of price and delivery time as well. Therefore, it is likely that changes to the TS may no longer be written into it as revision pages, but that they are recorded in the meeting minutes, in acknowledgments of change orders, and as changes in job number lists, and conveyed by these to everybody in the project. By the start-up of the machine, the original technical specification is no longer valid but information in several other documents, taken together, describe in detail the paper machine that was built.

4. On Boundary Between Communities of Practice

Between Valmet and the customer, the technical specification document has different meanings and uses for both sides. As a boundary object (Star 1989; Star and Griesemer 1989), it is flexible enough to allow these interpretations, but in individual site use, it becomes strongly structured, setting the limits to what kind of machine Valmet will build and in what kind of site it is to be installed. As a whole, it translates the wishes of the customer to Valmet, and what Valmet is promising to build to the customer.

Each side needs a clear set of standardized methods (Star and Griesemer 1989, p. 393) by which their information is "disciplined" so that it could become a part of the translation, or, to use Boland and Tenkasi's concepts, each side would need to explicate their knowledge into a visible format in some way, available to the others, so that the other side can then comprehend and use it in their perspective taking. Examples of these methods are how issues are brought to the negotiation table as items on the agenda and how, only by initialing a page, the party becomes committed to the changes agreed upon during the negotiations. A series of boundary objects are generated, to maximize both the autonomy and communication between the camps. These boundary objects have been refined over decades of negotiations between machinery suppliers and buyers. During the sales phase, the subsequent versions of the technical specification and the meeting agendas and minutes, confirming the process, will become a "cascade" of boundary objects (Henderson 1991), culminating in a signed contract, with all pages of the technical specification approved by both sides.

As an agreement on the machine to be built, the technical specification contains the commitments from the customer to build the rest of the plant so that the machine fits in, and the commitments from the Valmet units that their machine fills its place. However, these commitments are never complete and never totally stable. The dilemma in the use of the technical specification is to work on something that is likely to be according to the commitment, but, at the same time, acknowledging the continuous need for negotiations, for repairs of breakdowns, with incomplete, possibly dated, information. This could be interpreted as intentional seeking of negotiation and acknowledgment of mutual influence (Robinson 1991) between the parties, when they repeatedly revisit issues until they are sufficiently well defined for both parties, yet leaving enough room for specific interpretations within a community of practice.

If the technical specification is looked at as a collection of sub-documents, these gain their near immutable quality when they leave the part of the organization where the knowledge of their meaning resides. After that, they might possibly be formatted by the sales assistants, but the content of the sub-documents is not changed by them or the sales engineers. These sub-documents now hold stable the intractable and heterogeneous materials from which they were composed, and which can now be conveyed, collated, and compared. However, the tailored quality of the paper machines dictates the need to modify the technical specification, and opens it up again for changes. From the viewpoint of the customer, the pages of the technical specification gain their immutable quality when they are initialed, when the changes have been approved by both sides. The chain of changes can be followed by tracing the versions of the technical specification. In Project G, this was achieved by retaining the whole history within the TS document, marked with asterisks. Thus the TS document contained the process of translations (Callon 1986) that had been required to reach the current status. In this way, it also provided its readers a means for legitimate peripheral participation (Lave 1991) in this particular community of practice, the negotiators of the sales.

To sum up, the technical specification is one of the key boundary objects between the customer and Valmet. Established tradition in the negotiators' community of practice means that the uses of the technical specification at this boundary are relatively well defined, and the inherent problems are understood, even though not simple or transparent. The TS changes constantly, and when it finally reaches closure during the early stages of the project, it also becomes secondary to designs and other documents that depict in more detail what is actually built. Between Valmet and the customer, the technical specification is initially (intentionally) weakly structured, to invite negotiations, but it becomes strongly structured, as it becomes fixed in the system of related boundary objects (Star 1989) within a community.

5. Conscripting Participants Within a Community of Practice

Within Valmet, the technical specification is a boundary object between the different units. Within the project team, however, the technical specification has a special role as one of the conscription devices (Henderson 1991, 1998b), enlisting and constraining participation in creating and maintaining it. In this, the technical specification is similar to a set of drawings for a turbine engine (Henderson 1991): its users must engage in inputting its elements and in revising them, if the specification is to serve its intended function for their particular purposes. Conscription devices are receptacles for knowledge created and adjusted through group interaction, aimed toward a common goal. Like all boundary objects, as they represent the group's negotiated ideas, they also structure how work is done in groups. We assumed that as a conscription device, the TS would not only support the coordination of the design and manufacture of this particular paper machine between various individuals and groups within Valmet and its subcontractors, but that it would also contribute to developing and strengthening their knowledge domain and practices, their perspective making. According to Boland and Tenkasi (p. 356), as a perspective strengthens, it "complexifies," that is, the detailed views of the machine implementation would start to emerge and take shape. However, with the TS, this did not take place, for reasons outlined next.

Even though the information in the technical specification was collected from the units that would use it again during the project, and even though the sales team consulted the units on changes during the negotiation process with the customer, the designers in the units still could feel that the connection between the information in the TS and the unit was lost or that involving the designers in the TS came too late in the project. Also, the machine concepts are likely to have changed while the sales negotiations took place. The PM engages in careful refeeding of the information back to the units when the project starts, so that the design teams can relate their detailed design guidelines to the TS. The TS alone is not sufficient to enlist the project team members to the project, but the input of the PM is vital.

> *The technical specification is the backbone for all we do. Feeding information to the project members is one of the most essential issues in the beginning....I usually hold these reading meetings, which ensure that the team members have received the documents, that they have read them, and that they have even understood them. Because very often the machine is different from the standard machine, I need to ensure that they have noticed the differences....In the beginning of the project, studying the technical specification takes up an enormous*

> *amount of time, because one needs to learn it and read through it all. But then, during the project, less and less. During the first weeks it is very important, you almost study it by heart, so that you yourself have internalized it and then you go through it with the guys. It is one of the main means for us to get the message through to them. [PM of Project G]*

When the project team members return to their units, to the unit project teams, they engage in perspective making within that community of practice. In this process, they relate the specifications to the paper machine concept and part standards in their design guidelines, listing out the differences. The head designer then discusses these differences with the PM, after which the unit project teams start making the designs. They may still use the TS, but finding relevant information in it requires practice, due to its size and structure.

> *It comes to us only when the project is starting. There are usually shortcomings. An item can perhaps be found there, but it is not included in the price calculations. Then it will go free or we need to invent a bit to get the money. It is like this also in the Project G. There was a whole mechanism in one part missing in the price calculations, even though that is included in the standard....We have to ask the PM whether this and this is included and he then asks the sales department....Reading the technical specification is pretty much about picking out information of what has been sold. It should be relatively accurate because it is the starting point for design phase. Usually it is according to the standards, but there can be a lot of extra sold and we need to dig it out from there. [12]*

> *The structure of the technical specification drives me crazy, it is so comprehensive. Information from different units is just piled up in there under separate headings, the information you are looking for can be found scattered in several places, you need to leaf through the thing. No page numbers in the table of contents, it is difficult to find anything. [6]*

Meetings with the customer can result in changes to the TS, and the usual procedure for the PM is to inform those concerned quickly and directly. The information is then confirmed, for example, in meeting minutes, or internal orders (job number list changes). This also relates to negotiating the relationship of TS to other conscription devices. The PM of Project G gave primacy to meeting minutes and job numbers, due to the size of the project. The project team members could then trace changes by reading these and the related correspondence, but this was experienced by some as not coherent enough, and requiring too much attention to find the relevant changes among all the information. Also, as soon as the customer requirements are met and the interfaces of the part to other parts are specified, they become translated into set conditions for the part and the specification loses its importance for this part.

> *What the machine is, is then written into the operating and maintenance manuals. They are quite important for us. When they are done, nobody looks at the technical specification any more, it might have old information and cause errors. The information in the manuals is very detailed, but the technical specification is not. If the technical specification was to be updated all the time, it would end up being equally detailed. The actual machine...is different on the detail level, it has a different tailoring, even though on the surface it looks quite the same. [12]*

To sum up, the technical specification acts as one of the conscription devices for the project members. The design teams clearly engage in mutual perspective taking with the TS, the design guidelines, and their sketches and drawings (Henderson 1991). However, in the company-level Valmet project team, this appears to be more problematic, due to the independence of the units (of whom the team members are only representatives), the planned nature of the project with boundaries spelled out, and the goal of sticking to the concept and standards. Only a minimum of information is exchanged, and that is usually related to exceptions. Thus the ideal situation, where "distinctive individual knowledge is exchanged, evaluated, and integrated with that of others in the organization" (Boland and Tenkasi 1995, p. 358) may not take place during the project (even though it may have taken place earlier, during R&D for the machine concept), and the "complexification" through perspective making may be hampered. The TS, for its part, does not support this, as it is a part of the contract and therefore its constant update and refinement is restricted. Therefore the TS is supported and gradually replaced by other conscription devices: internal orders and job number lists, designs drawings, database files, meeting minutes, correspondence, manuals, and the like.

Having a complete, up-to-date technical specification on paper or in a file, in one place, available to all, would thus be practical only in the beginning of the project. Also, as a set of documents, it is unwieldy and complex, and updating it would probably end in inconsistencies between different parts. Therefore, it is gradually left to the role of telling what was agreed in the beginning, with other documents taking over. When seen in this way, the necessary vagueness of technical specification as a conscription device loses its potential dangers within Valmet, and a "graceful departure" from it becomes a more focal issue.

6. Discussion

The main focus of our study was on establishing the value of the two concept pairs: boundary object and conscription device and perspective making and taking, in tackling the coherence-flexibility dilemma in designing computer support for collaboration. Both concept pairs have shown their fruitfulness on their own (Boland and Tenkasi 1995; Henderson 1991, 1998a, 1998b; Mambrey and Robinson 1997; Star 1993), but they have not been used together before. The two pairings that we studied with our case were the relationship of boundary objects to perspective taking and the relationship of conscription devices to perspective making. We started with two statements to focus our attention:

- When knowledge is made available to others, it becomes a boundary object, providing a basis for perspective taking, for communication that improves the ability of the community to take the knowledge of other communities into account.
- When participants in a community of practice engage in creating and maintaining a conscription device, they engage in perspective making, in strengthening the unique knowledge of their community.

6.1 Perspective Taking and Boundary Objects

With our case study, the first pairing informed us of several issues. First, when we looked at the technical specification as a boundary object between Valmet and its customer, it appeared flexible enough to invite the necessary negotiations between the parties, i.e., for perspective making in this community of practice, yet sufficiently strongly structured to act as the statement of commitments of a party, i.e., as material for perspective taking. Second, the negotiations with the standardized methods over a boundary object, the TS, gave each party an opportunity to give information for the perspective taking of the other party. That is, in this "perspective giving" the extent of perspective taking of one party was "allowed" by the other party. Third, when the history of the negotiations was explicitly spelled out in the TS, the perspective taking extended also to past negotiations, and allowed the TS as a boundary object tp span further than the negotiations at the moment. In terms of learning, the negotiations and the TS with its included history provided an important means for learning not only for negotiators, but also to related parties who followed them, in the form of legitimate peripheral participation (Lave and Wenger 1991). Finally, the TS was combined from many sub-documents and it was itself part of the contract. These documents could be studied as a system of boundary objects (Star 1989), to outline their connections, also in terms of further perspective taking.

The first pairing also brought attention to possible problems of increased support for perspective taking. Paper machinery delivery projects form a nexus of engineering competence in Valmet. If the information and knowledge that is necessarily involved in this is made visible to a larger audience than before and if thereby the processes become more transparent, it is likely to have consequences in the power relationships between the communities of practice (Zuboff 1988). The standardized methods (Star and Griesemer 1989) that are being used between Valmet and the customer, with shortcuts and leaks and playing with time, could be jeopardized by too much transparency. Examples of the negative consequences for Valmet could be loss of slack time that is used to give room for recovery of (unavoidable) errors, and loss of ability to smoothen the wrinkles in own performance prior to making it public. These kinds of losses could be detrimental for the whole company, limiting its flexibility and responsiveness.

Henderson tells of people who feared that small errors would have monumental consequences, and how these fears created an atmosphere of secrecy: "The fluidity and flexibility that is part of the loose structure of boundary objects was paralyzed by the fact that the whole system was computerized....The huge size and complexity of the interlocking systems intimidated people" (Henderson 1991, p. 464). If the TS was more complete and detailed, by the sheer amount of interrelated information, the TS also would be at risk to losing its informing capability across the Valmet-customer boundary.

Not only the flexibility of interpretations could be at risk, but it would also be possible that any contradictions, possibly existing as dormant in the Valmet-customer relationships, could unexpectedly surface.

To summarize, boundary objects and perspective taking pairing helped to draw attention to

- the necessary flexibility and openness of the boundary object,
- the need to limit communication with it at the same time,
- the gradual, dialectical nature of the negotiation process,
- the boundary object as informing the negotiation and as its result, and
- how the boundary object was employed in perspective taking (and giving).

6.2 Perspective Making and Conscription Devices

The second pairing, conscription device and perspective making, also informed us of several issues. First, perspective making took place with the TS only early in the project, with the active intervention of the project manager, due to the nature of the Valmet project team. It met as a whole only in the beginning of the project and, after that, the communication was mainly between the PM and each individual project team member. The Valmet project team was only a short-term virtual construct,[1] not a long-living "community of knowing" (Boland and Tenkasi 1995). The permanent communities of practice for the team members were their respective design groups.

Second, because the creation of the TS was unidirectional, and it could only be changed via negotiations with the customer, other documents, kept fully within Valmet, gradually replaced it as the description of the paper machine to be. These other documents, therefore, become conscription devices, more focal to perspective making.

Third, due to the relatively general level of description, the TS was not very useful to the design teams, after the layout of the machine was fixed. After that, the current design guidelines for the type of machine became the guidelines to follow, with the possible risk that the current machine concept would be more influential in design than the machine ordered. However, this risk was actually not a risk, since Valmet openly professes to supply the latest technology, whether the customer knew to ask for it or not. The preference to design guidelines was further enhanced by the cumbersome format of the TS: finding relevant information in the TS was difficult and required considerable practice.

Fourth, information about the changes to the TS were distributed by several means. Keeping track on all relevant changes required active reading, and even then some may have passed unnoticed. This can be taken to indicate that, after all, a comprehensive, up-to-date, detailed description of the machine, accessible to project team members, could

[1]The problem of the loose connection between members of the Valmet project team has been addressed already with the Tasman application (Karsten et al. 1997), designed to hold most of the shared documents in the project; that is, the virtual nature of the project team has been acknowledged and it has guided the kind of support mechanisms that have been built. Our case, Project G, was one of the first project teams to experiment with Tasman use Valmet-wide, holding meeting minutes and monthly reports there. A wider coverage and use were still only discussed, to be addressed in later projects.

be the kind of conscription device that would aid perspective making within Valmet. However, this comes with risks attached, according to Henderson, who has drawn attention to boundary objects that could be too comprehensive and accessible. In her view, the difficulties the employees encountered in interacting with a repository reflected the difficulties the departments had in interacting with one another. If there were problems between Valmet units, they could become more visible with this kind of machine description.

The plans in Valmet seemed to approach this issue via the ERP system, which would tie together not only the specifics of the machine, but also connect it to more formal data such as in budgeting, resource planning, ordering, and scheduling. The problem of extensive coherence across the whole of Valmet, and thereby decreased flexibility for units, however, directs the attention to less controlled alternatives, such as document databases with (hyper)links to the relevant, more formal data, possibly in the ERP system. These would shift the balance to the other direction, as document-based, semi-formal and loosely structured alternatives could result in loss of controllability and manageability of the information.

In summary, conscription devices and perspective making pairing drew attention to the fact

- that loss of ownership, limited maintainablity, decreasing relative importance, and wieldy structure narrowed the usability of the TS as a conscription device in perspective making;
- that perspective making was seen to take place only in "real" teams, such as design teams, but only with special effort in "virtual" teams such as the Valmet project teams;
- that a "functional" conscription device could have the potential of supporting perspective making but also dangers; and
- that in considering the technical solution, how coherence and flexibility are balanced has consequences in perspective making, and vice versa.

7. Conclusion

The approach taken in this study was to look at one set of documentation, the technical specification of a paper machine, in crossing the boundary between Valmet and the customer, and in conscripting participation in the Valmet project team. On the boundary, it proved to be flexible enough as a boundary object, and diffuse enough to invite the necessary negotiations over it, with the resulting perspective taking. However, as a conscripting device within Valmet, it had several shortcomings, especially in relation to its limited changeability, to its relatively diffuse relationships to other conscripting devices, and to the practical difficulties in using it.

In parallel to Brown and Duguid's observations, in our case, the information was moving within Valmet in a rather sticky way, but much more fluently between Valmet and the customer. Brown and Duguid's explanation was that knowledge is continuously embedded in practice and thus circulates easily within a community of practice. Between the negotiating parties of Valmet and the customer, the long established practices of sales, contract negotiating, and cooperation during the project may have made them *de facto* communities of practice. There are not many paper producers with which Valmet has not had projects, and even when the individual persons have changed, the practices have remained to a great extent the same. Within Valmet, however, the units are geographically dispersed, and after the organizational changes of the past years, they are prone to establish their own practices in supplying parts or services for the paper machine projects, not necessarily in alignment with those of other units.

In terms of designing computer support for collaboration, our approach drew attention to several issues. First, the nature of boundary objects and conscription devices appeared to be open and modifiable in perspective taking and making. As soon as any deterrents were put in place to make changes difficult, the objects seemed to lose their function. Second, the dialectic between the object and the process seemed to work in both directions: the conscription device was the means of perspective making and perspective making resulted in changing the conscription device; and the same appeared also for boundary object and perspective taking. A concern related to this is how to increase action visibility, while at the same time acknowledging the need to bound the resulting transparency.

Our study thus indicates that balancing of flexibility and coherence is bound to be an active, situated process. Our study gave no directions as to how this dilemma could be solved in practice; it only drew attention to the dialectic nature of boundary objects and conscription devices in perspective making and taking. Thus our view of design process correlates with that of Bowers (1991), who sees systems development to be relational, reflexive, critical, and practical; proceeding from locally constructed and modifiable solutions, to shared work practices spread via interlinked and intertwined communities of practice, and in this way balancing coherence and flexibility.

To conclude, the key dilemmas we have identified are, how to ensure the availability of correct and sufficient information when needed, but at the same time provide enough background to assess the information; and how to increase action visibility, while at the same time acknowledging the need to bound the resulting transparency. The problem is also to understand the contingencies that affect the level of coherence and flexibility needed. An area for further work would be viewing these issues from the information system implementation perspective, with a consideration for technological resources and infrastructures.

Acknowledgments

We would like to thank Valmet and all our informants there for the free and generous access to their activities. Special thanks go to Mr. Jorma Hujala, head of the project department during this study, and to the project manager of Project G, for comments and clarifications on the earlier versions of this paper. The reviewers of the conference have also given valuable, much appreciated, feedback.

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