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Boundary Objects in Networked Learning Environments

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Designing for Collaboration and Mutual Negotiation of Meaning – Boundary Objects in Networked Learning

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ABSTRACT
This paper addresses the issue of collaborative learning and networked learning within continuing professional development. Collaborative learning is defined as the meeting of specific differences and dependencies among participants and practices within and across communities, afforded and constrained by the pedagogical design. The study explores how boundary objects serve as resources to support collaborative learning as a means of representing, learning about, and transforming knowledge. Based on a case study of course group work in a networked learning environment organized as problem oriented project pedagogy, the paper identifies the different kinds of boundary objects applied. Resting on the analysis and a typology suggested by Carlile on boundary objects and types of knowledge, the paper throws light on the students' complex process of working together, and the different forms of knowledge brought into play. The analysis suggests methods of optimizing teaching and learning processes through conscious use of boundary objects. Theoretically, the analysis questions the typology suggested by Carlile and introduces a relational view on boundary objects and how they relate to the different forms of knowledge.

Keywords
Networked learning, boundary objects, problem oriented project pedagogy

INTRODUCTION
One of the core issues within networked learning based on collaborative dependencies is to understand the conditions for collaboration and communication primarily mediated by information and communication technologies.

Learning and collaborating at the boundaries of different educational backgrounds and levels, professions, gender, ages, interests, etc. are general problems within professional, distributed problem solving. Building on the work of practice studies (Carlile 2002; Star and Griesemer 1989; Wenger 1998), the problem can be formulated as a problem of transcending boundaries. The problem of transcending boundaries is complex due to lack of shared language, habits, routines, and world views and lack of an interdisciplinary work tradition. Furthermore, as formulated by Carlile: *"Individuals are invested in their knowledge as hard-won outcome (...) They are reluctant to change their hard-won outcomes because it is costly to change their knowledge and skills"* (Carlile op.cit. p. 445). A practice approach to boundary learning therefore assumes that the conditions for knowledge building and knowledge sharing have to deal with differences, dependences and novelty on one hand, and resistance towards change on the other hand. Moreover, an assumption is that engagement in the collaborative learning process, and possible resistance are closely related to the construction of identity and the learning trajectory of the participant (Wenger 1998). Therefore, an analysis has to be situated within a broader perspective of the participants' overall engagement in the learning environment.

METHODOLOGY
In order to be able to empirically describe and theorize about boundary objects and collaborative learning, an operational framework based on studies (Carlile 2002; Star and Griesemer 1989; Wenger 1998) has been developed. The paper identifies the different kinds of boundary objects through a case study approach. The methods applied are analysis of recalled data (from the VLE-system Virtual U), a 'thick description' and 'rich pictures' of the knowledge construction process. The case study focuses on the very first days (8 days) of the

work in a course group with 5 students within Master in ICT and Learning (MIL) – which is a networked learning environment based on 'problem oriented project pedagogy' (Dirckinck-Holmfeld, 2002; Fibiger et.al., 2004). Resting on the analysis and discussing a typology suggested by Carlile, the paper introduces a relational view on boundary objects and the manner in which they are employed in the virtual learning environment. The researcher perspective is combined with roles as co-manager and co-designer of the program.

BOUNDARY OBJECTS

In the seminal paper by Susan Leigh Star and James R. Griesemer (1989), boundary objects are defined "*as analytic concepts of those scientific objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them"* (op. cit. 393). Star and Griesemer suggest four categories of boundary objects. The categories have emerged from the study of institutional ecology, and were developed in close relation to the study of 'translation tasks' initiated by the biologist, Joseph Grinnell.

"1. Repositories. These are ordered 'piles' of objects, which are indexed in a standardized fashion. Repositories are built to deal with problems of heterogeneity caused by differences in units of analysis.

2. Ideal type. This is an object such as a diagram, atlas or other description which, in fact, does not accurately describe the details of any locality or thing. It serves as a means of communicating and cooperating symbolically – a 'good enough' road map for all parties.

3. Coincident boundaries. These are common objects with common boundaries but different internal contents.

4. Standardized forms. These are boundary objects devised as methods of common communication across dispersed work groups. The result of these types of boundary objects are standardized indexes and what Latour is calling 'immutable mobiles' (objects which can be transported over a long distance and convey unchanging information). The advantage of such objects is that local uncertainties are deleted.

Analysis of the use of boundary objects

The group gave us insight into different kinds of 'boundary objects', which are used to align the group work. Based on the analysis (see the rich pictures below and further rich pictures, thick descriptions, and the table in the annex on the web: Dirckinck-Holmfeld, 2005), I suggest the following kinds:

- Group products
- Ideal types of frameworks, concepts, models
- Standards and guidelines - Group regulated as well as MIL /teacher regulated
- Communication infrastructure, which at the same time functions as coincident boundary object for the group.

Among these objects, *the group products* seem most important as a boundary object; with the problem formulation and the outline as the most challenging, but also the ones promoting the best learning opportunity. In the process of problem formulation and making the outline, different kinds of learning and collaboration take place: 1. Learning about (assimilating knowledge); students share references, new concepts, new methods, new world views, and by this, they extend their knowledge base. 2. Transforming knowledge (accommodating knowledge); students transform their knowledge base struggling with new concepts, references and frameworks and get novel insights about meaning, relations, application, world views, etc. This process is both an individual and a group process. The individual student is struggling with the different kinds of input, while the process is pushed forward by their shared responsibility for the group work. Furthermore, the peers are used as a community, where they 'think aloud', update each other on new insights and share references, and also a forum in which they discuss the different interpretations and applications of tools and concepts.

Using Wenger's framework (1998), the product becomes the shared enterprise of the group and the nexus for negotiation of perspectives. Especially the problem formulation phase affords enacting different worldviews, theoretical concepts mixed with reflections on practice. The different worldviews and knowledge backgrounds of the group seem to provoke useful reflections and discussions. The other phases of the course group work, writing the different parts of the assignment and finalizing the assignment also provoke learning. However, the

kind of learning is of a consolidating character, mixed up with pragmatic reactions to the situation. At this phase, the goal becomes to submit the assignment on time – and to pass.

RICH PICTURE

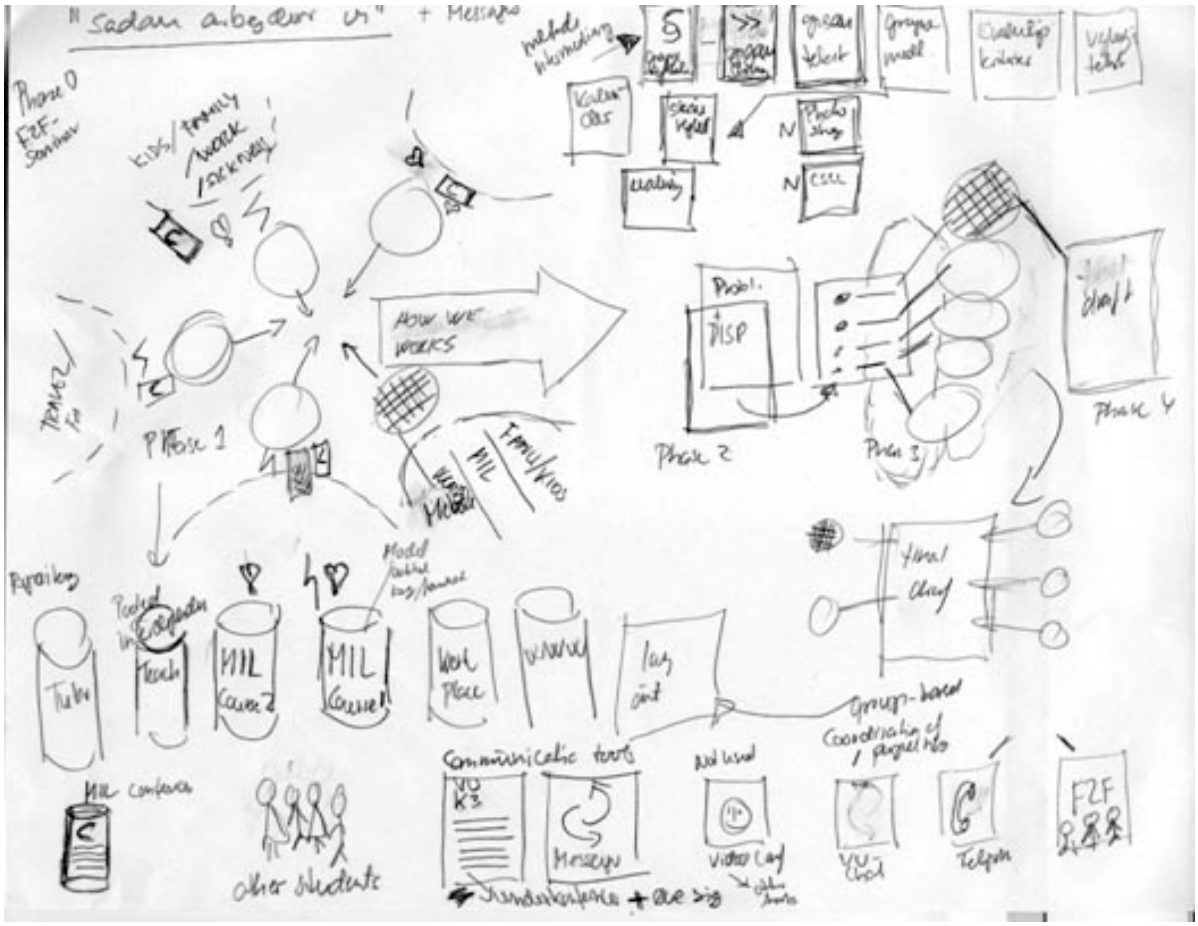

Fig. A1: "Sådan arbejder vi". Capturing the entire process of the group work during eight days employing different kinds of boundary objects.

Based on the analysis of the group, the shared *product,* i.e. the project seems to be the strongest boundary object, which enables them to represent, learn about, and transform knowledge boundaries. In the process of dealing with the project, the compulsory literature (and literature in general) as examples of *'ideal types'* of boundary objects seem to be of vital importance.

The repository of concept frameworks provided by literature and discussions, supports the establishment of a shared repertoire among the students, and provides insights into different world views and interests. The (compulsory) literature functions as a shared object, to which the participants can relate and discuss. It promotes the process to have a shared object in the sense that "what you see is what I see". These shared objects (frameworks, concepts, models) are used as a shared point of departure for trying out different interpretations, as well as these objects serve as a starting point for developing their own concepts and frameworks.

In order to function as a boundary object, it is crucial that the students have access to the same materials. This possibility has been renewed in the virtual learning setting with the World Wide Web, which has enabled the students to access the same materials and made it easy (and cheap) to distribute electronic materials to each other. For the group, the conference system and the Virtual U course template serves as the place, where these materials are distributed. Furthermore, it turns out that links on the web are more likely used to check references

and concepts than asking the teacher. The teacher is primarily used indirectly through the answers to the other groups to provide 'standards' for the course work, and to check whether the problem formulation and the work in progress is OK.

Literature and especially compulsory literature function as a boundary object in the sense that all participants relate to it. Especially models seem attractive in order to coordinate the perspective of the group (cp. their use of Engeström's triangle), as so these kinds of '*ideal types*' enable them to represent, learn about and transform knowledge boundaries for the single participant and between the participants.

In the course group, we see two kinds of *'standards'* as boundary objects: the self regulated developed by the group, and the 'standards' developed by MIL/the teacher. For both objects it is fair to say that they are only 'standards' in a very weak sense. They are guidelines and norms, which are fairly open for interpretations, and, in most of the cases, there are no direct consequences of not following the 'standards'. The only anomalies in this respect are the assignment text, where a different or wrong interpretation from that of the teacher /MIL may have a failed course as its consequence. However, even these 'standards' are weak; they serve as important subsidiaries for the work to be done. Using the terminology from Polanyi (1958), the focal awareness is on the problem formulation and the appropriation of the literature and concepts, while the group regulated standards, the agreement, the calendar, the communication rules, etc. are necessary subsidiary tools for doing the work. They are subsidiaries in the sense that they are means for the focal activities to take place. Because the group has agreed upon and are following a 'standard' for how they are going to work together, they can concentrate on dealing with the problem formulation and the project.

As can be seen in the transcripts, there were some 'break downs' in the collaboration process, primarily in the progress of the problem formulation and the outline related to the plan. However these were not seriously threatening the foundation on which the group has built their commitment, so in that sense, the subsidiaries did their job, functioning as subsidiaries for the focal awareness.

'Standards' may be divided between the self-regulated standards by the group and the standards and guidelines provided by MIL and the teacher (the formal organization). Self-regulated standards give ownership to the process, which, at least in a Scandinavian context, is appreciated as valuable. However, they also open for discussions and negotiations, which may take up time and resources. The group handled this process very instrumentally by using the guidelines from the seminar and skills on management from their professional life.

The 'standards' provided by the teacher/MIL seem to fulfil the students' need for assistance in the coursework. The clear structure for when and how the teacher would assist their work provided safe conditions for their work. Even though this group did not contact the teacher directly, his advice to other groups (in the course conference) was used by the group to align their work. This indirect advice from the teacher was followed very directly. In other words, the teacher's/MIL's 'standards' were taken at (their) face value. It seems extra important in a virtual learning environment that these 'standards' are of high quality and convey reliable and accurate information, so that they actually function as subsidiaries for the students, and not become the focus in themselves.

'*Standards*' act as subsidiaries for the shared work on the product. Standards express certain ways of doing, which have been agreed – or accepted - across community boundaries.

Another crucial boundary object in virtual learning environments is the *communication infrastructure*. In this case, the communication infrastructure consists of the following tools related to the group's course work: The conferences in Virtual U, the course template in Virtual U, the Messenger-unit (Virtual U chat), and the physical seminar. The communication methods served different purposes. The conferences in Virtual U were the most important. Through written discussions and messages, the students updated each other, shared views on articles, sent citations and interpretations to each other, etc. The flexibility of a conference system is obviously a strength for such a group of busy people, as it provides elasticity for each of them, to communicate when it is convenient. The independence of shared geographical space is another important feature, which obviously enables the students to stay in contact, and also makes it possible for group members to stay in contact even when they are travelling. The written communication in conferences has both strengths and weaknesses as documented in many studies. In this group, they were very aware of the Achilles' heel connected to this form of communication, and they set op norms for good communication, as well as they integrated other tools to support their work.

Navigating in conferences may be challenging, when conferences include several hundred postings. On these grounds, it becomes a challenge to summarize, to create order and to understanding and to reify the meaning created in order to prevent the process from going in circles or dissolving, loosing the focus of the project. One way to create a better overview and meaning of the course conferences is to use sub-conferences in order to organize the different processes in the project, which the group did. This way of handling the communication process made a clear structure for the group, and it became easier to reify the meaning conveyed.

Nevertheless, conferences are difficult media for navigation and overview when the amount of postings becomes large. Although the negotiation process has been reified in the conference threads, the meaning may easily disappear in the overwhelming complexity. Neither does summaries, trying to reify the meaning in unifying documents, imply that the constructed meaning becomes an active part of the shared repertoire of knowledge of the course groups. In asynchronous conferences, summaries and other constructions of meaning will easily disappear as just another posting among hundreds of others if not organized consciously.

The course template in Virtual U was used by the group to provide exactly these functions. The group and all other groups were given privileges to create their own "course" using the course template in Virtual U. The group used this template to make their own plan, to upload the different versions of the problem formulation, the outline, summaries from chats, literature list, first, second and third draft of the project, etc. Furthermore shared resources, e.g. articles and reports, and the shared 'standards' were uploaded. On this basis, the course template functioned as a shared object, which provided overview and easy access to all the relevant drafts and products for the project. The group also found a way to handle collaborative edition and dealing with version control, even though this was not a feature directly provided by Virtual U.

Finally, Messenger was used to continuously stay in contact and to immediately coordinate perspectives or practical issues, as well as Messenger (or the chat in Virtual U) were used for formal chat sessions among all participants, where the bigger decisions concerning the project were taken. In some earlier work on collaboration in CSdCL (Fjuk and Dirckinck-Holmfeld, 1996), coordination work really turned out to be the bottleneck – exactly because of lack of tools to support immediate coordination of perspectives as well as synchronization of bigger decisions. It is therefore interesting that Messenger seems to fulfil this need.

All the tools appeared to work smoothly for the group, and supplement each other as a well functioning communication infrastructure. Without any serious breakdown, the communication infrastructure indeed became an infrastructure embedded in the social arrangements of the group, without the students really recognizing it.

The communication infrastructure served as an *intermediary* boundary object between the group-members. The communication infrastructure provided different means, by which the participants could represent, learn about and transform knowledge boundaries.

Furthermore, the communication infrastructure was a *coincident boundary* for the group, providing their own territory. The MIL-communication infrastructure is a 'coincident boundary', to which all participants, students, teachers, supervisors, secretaries, and technicians relate. The overall shared boundary establishes a border between MIL and other communities. The password gives access to a community with whom you share interests and aims. Within this overall shared boundary, the course group has its own coincident boundary made up of their specific communication infrastructure. Some share boundaries with the other groups, e.g. the conferences in Virtual U, due to the open access policy, while other communication means are only available for individual groups (Messenger and the Virtual U course template).

The awareness of the shared boundary is important in building up the identity as a MIL-participant and a group-participant. Being inside provides special privileges. The coincident boundary makes it possible for the participants to see who belongs to this community, and provides a boundary against other communities – such as work, family, hobbies – and a boundary, which provides a safe arena for experimentation, collaboration and learning.

Infrastructure as a *'coincident boundary object'* provides an important boundary towards other communities, and it gives the participants a safe arena for representing, learning about, and transforming knowledge boundaries.

DISCUSSION

The point of departure for the analysis of the learning environment was based on the categories of boundary objects as proposed by Star and Griesemer (1989), namely the following categories: Repositories; ideal types; coincident boundaries; and standardized forms. Star and Griesemer did not claim that this list was exhaustive by any means.

Based on the analysis of the course group in MIL, two more categories have been added to the list of boundary objects: the communication infrastructure, which I suggest is labelled 'intermediary boundary objects', and the shared product(s). The shared product is viewed as the strongest in terms of learning in the sense that it prerequisites and affords the most engagement from the participants, as well as it implies mutual negotiation and alteration of the shared meaning. The study shows that different phases of the collaborative learning process can be found, with the problem formulation and the concluding phase as the most demanding in the sense that they require that the group interacts as a unified whole, while the other phases are more based on individual contribution.

The communication infrastructure is a boundary object at another level, and may be viewed as intermediaries. It is a prerequisite for the participant's exchange of information, discussions, updates, coordination of perspectives, etc. in a distributed community. However, the communication infrastructure also becomes part of the group's identity, a shared boundary through which they understand themselves as a group.

Carlile (2002) proposes a kind of typology of 'effective'[1] boundary objects. He suggests a categorization of boundary objects at three levels:

First, *"a boundary object establishes a shared syntax or language for individuals to represent their knowledge" (Carlile op.cit. p. 451)*. In that perspective it is fundamental for collaborative work and learning to have a shared language or syntax to deal with a boundary, and this is a prerequisite with any type of boundary object (standards, frameworks, concepts, group products, and repository). If the participants do not share the syntax or language, there will be a break down in the employment of the boundary objects, and the participants cannot do the work they intended to do.

Secondly, an effective boundary object at a semantic boundary *"provides a concrete means for individuals to specify and learn about differences and dependencies across a given boundary"*(Carlile op. cit. 452). Using the boundary object, participants will be able to identify differences and dependencies among them. Following Carlile, 'standardized forms and methods' and 'objects, models, and maps' have these characteristics, while a repository, according to Carlile, only functions at the syntactical level.

Thirdly, at a pragmatic boundary, pragmatic objects "*facilitate a process where individuals can jointly transform their knowledge"*. Participants can alter, negotiate, or change the object or the representation used. If an individual cannot transform the current approach to a cross-functional problem, their knowledge will have limited impact in a product's development. In order to count as a pragmatic boundary, individuals must be able to draw on, alter, or manipulate the content of a boundary object to apply what they know and transform the current knowledge used at the boundary (ibid. p. 452).

According to Carlile, 'objects, models, and maps' are the only category of boundary objects that directly supports the transforming of knowledge. However, Carlile also found that all three categories of boundary objects have a portfolio effect; repositories and standardized forms support the use of objects, models and maps as well as support processes of managing knowledge at a pragmatic level. Further, the knowledge transformed and created through the use of objects, models and maps can then be used to enhance the content of shared repositories and the use of standards (ibid. 452)

The relations between the different modes of knowledge and the boundary objects according to Carlile are presented in the table below:

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[1] With 'effective' he understands tools, methods, or objects that made them *useful* in joint problem solving at a given boundary.

Types of Knowledge Boundary	Categories of Boundary Objects	Characteristics of Boundary Objects
Syntactic	Repositories	Representing
Semantic	Standardized Forms and Methods	Representing and Learning
Pragmatic	Objects, Models, and Maps	Representing, Learning, and Transforming

Table 1. Type of Knowledge Boundary, Category, and Characteristics of Boundary Objects, Carlile (2002, p. 453)

The characteristics of the different kinds of knowledge boundaries and different kinds of collaboration and learning seem interesting. Based on the analysis, I am however reluctant to relate the different types of knowledge boundaries with the different categories of boundary objects. As found in the analysis, it seems as if all categories of boundary objects can mediate knowledge on different levels, either as representing, learning about or transforming. As an alternative, I will therefore suggest that the three different levels: syntactic, semantic and pragmatic may be related to all boundary objects.

If we take the standardized forms as an example, e.g. the group agreement worked out by the students, it has worked on all levels. When the group formulated the agreement on the seminar they were working on the semantic and pragmatic level. Certainly, some of them had newer thought about working together in a virtual universe, and they were negotiating and altering their ideas and experiences for group working to fit this new context. However, when they, in the following phase, were using this standard it was on the syntactic level – or we might call it the routine level. Only if there was a break down in the group they would return to the semantic and pragmatic level and renegotiate the group agreement.

The same could be said about a repository. A repository can be used if the students know the syntax, however if there is a break down, they have to understand the way in which it is organized and categorized on a semantic level. An example from MIL: If the students do not understand the semantics behind the syntax, it is nearly impossible to navigate in the virtual learning environment, because the syntax would be without meaning for the students, it would only be abstract numbers and letters. However, when they understand the semantics, the navigation structure gives meaning, and they may relate to it on a syntactic level.

I therefore propose that all three knowledge forms can be seen as related to the different kinds of boundary objects. When a boundary object supports the collaborative process on the routine level it functions at the syntactic level, however when there is a breakdown, the participants will have to go to the level of semantics or pragmatics in order to 'repair' the knowledge boundary.

Consequently, I suggest a relational view on boundary objects. What determines the 'efficiency' of a boundary object is *relational* to the situation, and to the objectives. In a shared collaborative learning process, the construction of the shared problem formulation is the strongest boundary object. However, in the case, which Star and Grisemer are referring to, the shared repository was maybe the strongest boundary object in the sense that all groups could contribute. Furthermore the aim was different. In the learning case, the enacting of transformative knowledge has the highest priority, while in the Star and Grisemer case, the intention was not to transform the knowledge boundary, it was more likely to broaden the knowledge base. Furthermore, the boundary object may function at different knowledge boundaries – from syntactic to pragmatic, but there is a dynamic relation between the different levels. When collaboration is smooth, it acts on the syntactic level (routine level), however when there is a breakdown, it prerequisites interchanges at the semantic or pragmatic level.

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