Cognitive Work Analysis and Work Centered Design of Classification Schemes

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ABSTRACT: Work centered design of classification schemes is an emerging area of research which poses particular challenges to domain analysis and scheme construction. A key challenge in work centered design of classification schemes is the evolving semantics of work. This article introduces a work centered approach to the design of classification schemes, based on the framework of cognitive work analysis. We launch collaborative task situations as a new unit of analysis for capturing evolving semantic structures in work domains. An example case from a cognitive work analysis of three national film research archives illustrates the application of the framework for identifying actors' needs for a classification scheme to support collaborative knowledge integration. It is concluded that a main contribution of the new approach is support for empirical analysis and overall design of classification schemes that can serve as material interfaces for actors' negotiations and integration of knowledge perspectives during collaborative work.

1. Introduction

Work centered design of classification schemes is based on the view that semantic structures are dynamically evolving in work situations. Former views on classification have mostly been based on more static assumptions concerning semantics, such as deep semantic structures underlying all natural languages (e.g., Chomsky, 1971). The domain analytic approach (Hjørland and Albrechtsen, 1995) emphasized a more dynamic understanding, according to which the semantic structures are developed in domains or disciplines and reflect their needs of informational tools in those domains. The work centered design approach takes this dynamic approach one step further by focusing on the actual dynamics in a work situation. The aim of this article is to contribute with a new work centered approach to design of classification schemes, based on the methodological framework of cognitive work analysis (Rasmussen, Pejtersen and Goodstein, 1994; Pejtersen and Albrechtsen, 2000; Albrechtsen, 2003). The suggested approach differs from previous Information Science contributions to the field, which primarily

deal with detailed design of classification schemes, based on guidelines and standards for scheme construction (e.g., Ørnager Ornager, 1997; Nielsen, 2001). The focus of this article is on how to capture work domain semantics through analysis of collaborative task situations where actors formulate semantic structures. Cognitive work analysis offers a methodological framework for empirical analysis of work and identification of semantic structures of work content. Furthermore, it offers a corresponding framework for work centered design and evaluation, which can guide the transformation from empirical analysis of work to design of information systems and classification schemes (Rasmussen, Pejtersen and Goodstein, 1994; Vicente, 1999; Sanderson, 2003; Pejtersen, 1994; 1989). The focal point of the present article is cognitive work analysis of collaborative knowledge integration in the film archive domain and the corresponding identification of semantic structures, exemplified through the case of collaborative negotiations of information needs at a national film archive.

The article is structured as follows: Section 2 introduces the key challenge of capturing work domain semantics for classification schemes. Section 3 addresses related work. In section 4, the methodological framework for cognitive work analysis is introduced. Section 5 deals with the two main analysis perspectives of the framework that guide empirical analysis for design of work centered classification schemes: means ends analysis and decision task analysis. In section 6, an example is taken from the film archive research domain of a prototypical decision task of knowledge mediation that involves collaborative exploration and integration of knowledge. The example illustrates the use of the framework for capturing evolving semantic structures in collaborative knowledge integration and the corresponding need for a classification scheme. Section 7 provides an overview of the analysis and overall design cycle for work centered classification schemes. The conclusion, section 8, summarises the main points of the article and outlines future research.

2. Work domain semantics and classification schemes

A key challenge in work centered design of classification schemes is that the schemes must be rooted in the semantics of the work domain. Because of the evolving nature of work, the corresponding domain semantics is dynamic. Work is a social phenomenon and can be understood in multiple macro-social contexts, for instance, in the light of culture, economy and organization (e.g., Hall, 1994; Hodson and Sullivan, 1995). The phenomenon of work can also be understood and studied as the sociology of workers or human actors at work, directed towards understanding of human experience and activity in work domains (e.g., Auster, 1996). When human actors enter and engage in the sphere of production, they become subject to informal socialization and adaptation, irrespective of professional specialty, that is, regardless of their formal socialization in education and training (Schmidt, 1990). This implies that work domain semantics is not only an effect of actors' individual knowledge and interests and their professional paradigms or languages, but is as much an effect of their ongoing construction and integration of knowledge during work activity (e.g., Schmidt and Wagner, 2003; Albrechtsen, 2003; Albrechtsen, Pejtersen and Cleal, 2002; Gerson and Star, 1986).

The challenge of capturing work domain semantics and the corresponding challenge of work centered design are focal points of the current basic research on work centered classification schemes, carried out at the Cognitive Systems Engineering Centre, Risø National Laboratory (Pejtersen and Albrechtsen, 2000; Pejtersen and Albrechtsen, 2002; Albrechtsen, Pejtersen and Cleal, 2002; Albrechtsen, 2003). At this stage of research, we define classification schemes as symbolic artifacts, which inscribe stable semantic structures of work and make visible the semantics to support actors' decision-making activities. Currently, we are involved in large-scale empirical work analysis and evaluation of the design of a web-based film research collaboratory, Collate (Cleal et al, 2004; Andersen et al, 2003; Pejtersen et al, 2001). The aim of this research is to further develop methods for cognitive work analysis of collaborative work, which may inspire overall design of classification schemes that can mediate and support collaborating actors' articulation work and sense-making in work domains.

3. Related work

The last few years have seen an increasing research attention to design and use of classification schemes in work domains. The research object can be understood broadly and in an open way as construction, adaptation, maintenance and use of classification schemes to support people's work activity. From an Information Science perspective, classification

schemes are defined as tools for ordering and retrieval of documents in collections or repositories held and maintained by organizations like libraries, archives and private companies (cf. e.g., Olson, 2002; Svenonius, 2000; Hjørland and Albrechtsen, 1999; Miksa, 1992; Soergel, 1985). In work domains, human actors may create common repositories or common information spaces (e.g., Bannon and Bødker, 1997) and develop and apply classification schemes for the ordering, searching and sharing of knowledge. In addition, classification schemes can support the actors' mutual articulation of work and their joint decisions (Schmidt and Wagner, 2003; Gerson and Star, 1986). Articulation of work occurs in actors' communication and negotiation about work tasks, knowledge sharing and planning and analysis of work problems. Explicit procedures, or models for actors' decisions, may exist in the shape of documents with policy formulations or in the shape of common representations like classification schemes. Actors' decisions can also follow implicit procedures, learned or developed during their professional training or training and collaboration at the workplace. In such a work-analytical perspective, work domain semantics is on the one hand *inscribed* in stable procedures and common representations, but is at the same time continually *performed* and *negotiated* during the actors' ongoing communication and negotiations about work content (e.g., Simone and Sarini, 2001; Pejtersen and Albrechtsen, 2000; Carstensen, 1997; Middleton (1996); Schmidt and Bannon, 1992; Suchman, 1983).

Design of classification schemes for work domains can be based on data capturing from documents like product and process documentation created in a work domain, and a corresponding mapping of data into a classificatory structure (e.g., Prieto-Diaz, 2002). Design of classification schemes for work domains can also be based on statistical analysis of diverse and common terms used by human actors in work organizations, when they search for information, and a corresponding organization of terms into classificatory models like thesauri (e.g., Nielsen, 2002; Ørnager, 1997). From an analysis perspective, these approaches emphasize formal analysis of semantics through concept or term mapping into universal models for organization of knowledge (see e.g., Lyons, 1977, for a discussion of formal analysis of semantics).

As Schmidt (1990) has pointed out, a problem like diverse terms in different organizational units of a work domain, such as terms like 'part', 'project', 'subassembly', and 'tolerance' within a manufacturing company, is not merely terminological. The problem is multiple incongruent perspectives for conceptualization of work, as observed by Gerson and Star (1986), Star and Griesemer (1989), Pejtersen, Sonnenwald, Buur, Govindaraj and Vicente (1997), Davenport (2001) and Albrechtsen and Jacob (1998). Such diversity of conceptualization can be an effect of specialization of the workforce in professional roles, discourses and disciplines, as pointed out by Hjørland (2002 et passim). New conceptualizations can evolve during collaborative practice and decision-making amongst actors in work domains. For example, the problem of defining 'tolerance' of a particular product design in a manufacturing company will require dialogue and negotiation amongst the actors involved from different parts of the enterprise, in order to get the work of establishing criteria for quality assurance done (cf., e.g., Schmidt, 1990; Pejtersen et al, 1997). It is our assumption that analysis of collaborative task situations, where actors are interdependent and need to develop a mutual understanding, can contribute to an understanding of how semantic structures evolve in work domains and how such structures can inspire the overall design of classification schemes to support collaborative knowledge integration in work domains.

4. Cognitive work analysis

Cognitive work analysis is a methodology for systematic exploration and analysis of work domains. The framework comprises a taxonomy to capture the context in which domain semantics evolves, together with models for analysing decision-making (Rasmussen, Pejtersen and Goodstein, 1994). The framework has been developed from empirical analyses of a diversity of work domains, based on extensive field studies in libraries, research archives and hospitals, as well as of product development in concurrent engineering and manufacturing (e.g., Pejtersen et al, 2001; Rasmussen, Pejtersen and Goodstein, 1994; Carstensen, 1997; Hovde, 1990; Rasmussen, Pejtersen and Schmidt, 1990; Pejtersen, 1994). The framework supports understanding and modelling of a work domain as a social system of work, which will then shape the basis for design of information systems. As pointed out by Vicente (1999), Rasmussen and Pejtersen (1994) and Schmidt (1990), the social system of work is an extremely complex phenomenon. It involves many forms of social interaction that are bounded by a number of external and internal

constraints. Internal constraints may include traditions and privileges of task allocation amongst the actors and the way they tend to regulate horizontal information flow amongst themselves. External constraints like the function of a particular enterprise or work domain in the socio-economical system, such as the external economical or political constraints for an educational institution or a manufacturing enterprise, will impact the local regulations of work. The different forms of interaction in the social system of work do not exist as discrete entities, but are highly interdependent.

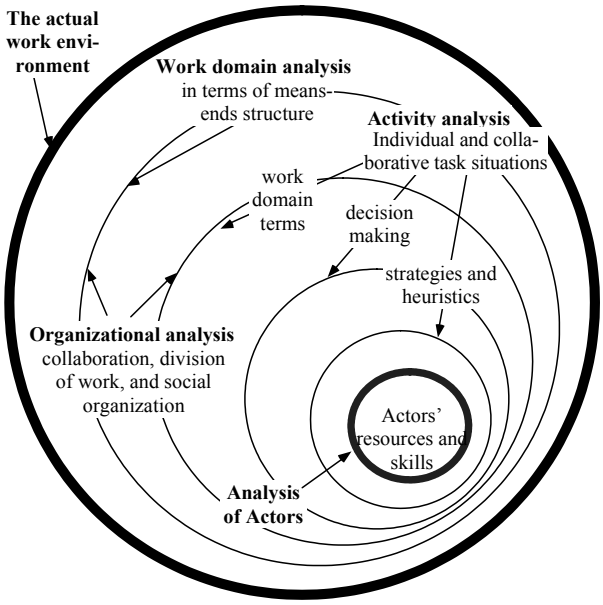

Figure 1 The different perspectives involved in cognitive work analysis (the Onion Model).

Cognitive work analysis approaches this complexity through an analytical distinction between different layers or perspectives of work. The Onion model (Rasmussen, Pejtersen and Goodstein, 1994) guides empirical study and interpretation of the social system of work (figure 1). The Onion model provides an overall taxonomy for characterizing the stable patterns of work. The onion model comprises the following abstract layers or perspectives:

Means-ends perspective of the territory of work
Work organization perspective
Task situation perspective
Decision task perspective
Mental strategy perspective
Actors' knowledge perspective

Some analysis perspectives of the Onion model capture macro-level contexts like culture, economy and professional paradigms and values, as evidenced by the means-ends perspective (layer 1) and the actors' knowledge perspective (layer 6). Other perspectives emphasize the actors' situational work activity in individual and collaborative work and their interpretations of the territory of work (layer 3). Based on the guidance of the Onion model, a concrete conceptualization or model of the social system of work is progressively created.

5. Design of classification schemes based on domain and decision task analysis

Pejtersen (1994; 1989; 1986) has developed the principle for work centered design of classification schemes, that recurrent properties of information needs arising in communicative interaction between actors reflect structures of a multidimensional semantic territory, and that such structures can be used in the design process of modelling classification schemes. This notion is based on extensive field studies of collaborative task situations of fiction mediation (searching and indexing), where recurrent patterns of formulations of properties and dimensions in information needs were identified. The fiction mediation dimensions were transformed to a classification scheme with an attribute structure, supporting all decision processes in searching and indexing, from negotiation of perspectives to planning of actions.

Work centered design of classification schemes builds on two main perspectives: means-ends analysis and needs analysis (corresponding to layers 1 and 3-4 of the Onion model). The two steps of analysis can be carried out concurrently, in order to build up an understanding of how the actors' activities and need formulations are coupled to the actual territory of work. The generic means-ends model guides means-ends analysis of the overall territory of work, which is involved in a collaborative task situation (Rasmussen, 1986). Analysis of actors' needs is addressed through identification of prototypical decision processes in a task situation and through the dimensions of knowledge levels and domain perspectives involved in the decision processes of collaborative work (Rasmussen, Pejtersen and Goodstein, 1994; Pejtersen and Albrechtsen, 2002).

5.1 Means-ends analysis of work and the abstraction hierarchy

Means-ends analysis deals with the overall territory of work as (i) domain structures and actors' work strategies on the one hand, and (ii) actors' resources, background and preferences on the other hand. Means-ends analysis is based on two analytical principles: (a) empirical analysis of work domains and (b) mapping of identified domain substance in a means-ends hierarchy (Rasmussen, 1986; Rasmussen, Pejtersen and Goodstein, 1994). The generic means-ends abstraction hierarchy is displayed in figure 2.

MEANS-ENDS RELATIONS	*PROPERTIES REPRESENTED*
Goals and Constraints	Properties necessary and sufficient to establish relations between the performance of the system and the reasons for its design, i.e., the purposes and constraints of its coupling to the environment. *Categories are in terms referring to properties of environment.*
Priority measures	Properties necessary and sufficient to establish priorities according to the intention behind design and operation: Topology of flow and accumulation of mass, energy, information, people, monetary value. *Categories in abstract terms, referring neither to system nor environment.*
General Functions	Properties necessary and sufficient to identify the 'functions' which are to be coordinated irrespective of their underlying physical processes. *Categories according to recurrent, familiar input-output relationships.*
Processes and Activities	Properties necessary and sufficient for control of physical work activities and use of equipment: To adjust operation to match specifications or limits; to predict response to control actions; to maintain and repair equipment. *Categories according to underlying physical processes and equipment.*
Physical resources	Properties necessary and sufficient for classification, identification and recognition of particular material objects and their configuration for navigation in the system. *Categories in terms of objects, their appearance and location.*

Figure 2 *The means-ends abstraction hierarchy*

The abstraction hierarchy has five levels, from goals and constraints to physical resources. The highest level of *goals* (i) addresses the purpose of the work domain in relation to its functions in the environment. This level applies to the domain's anchoring in cultural, political and economical systems. *Constraints* imposed by outside regulations like legislation or codes of practice are addressed in this abstraction level as well. The second level of abstraction concerns *priority measures* (ii). This describes how resources like staff, material and finances are allocated within the domain. The feature addresses how the distribution of activities and materials are managed within a domain, through organizational structure and division of labour and resources. The third level of abstraction is general *functions* (iii). This feature concerns the recurrent tasks carried out in a domain, irrespective of the physical resources like staff or work tools involved in carrying out these tasks. The fourth level of abstraction focuses on *physical processes* (iv) involved in work activities, which are necessary to establish and maintain the general functions of the work domain. The fifth and lowest level of abstraction covers an inventory of *physical resources* (v), which are created, used and maintained within the domain. 'Physical resources' also cover the actors involved in activities in the domain, such as staff and users (Rasmussen, Pejtersen and Goodstein, 1994, pp. 35-55). The relations between the content or substance matter of the means-ends abstraction hierarchy are not static, nor are they logically or causally given. The relations are given by the actors' interpretations of the territory of work.

5.2 Analysis of decision processes

Cognitive work makes use of decision templates as heuristic tools for capturing and analyzing collaborative decision processes. A decision template can consist of the following components: a) what is the situation we are dealing with?; what are the options?; and what are the constraints?; b) what kinds of plans can we make on the basis of this analysis?; and c) what do we want or do not want to do, based on the result we got? (see for instance, Brehmer, 1992; Richardson, G. P and J. Rohrbaugh, 1990). Based on Pejtersen's principles for analyzing communicative interaction in information seeking (e.g., Pejtersen, 1994, 1989, 1986), Pejtersen and Albrechtsen (2002) defined the following decision template with three components for analysing the collaborative negotiation of an information need:

Component 1: Situation analysis
The situation analysis is initiated by the activation of the actor's attention to the possible aspects of an information need, and it involves observations, questions, problem identification, exchange of perspectives, conceptualizations and identification of options. These are all analytical processes.

Component 2: Evaluation of options
The implications of the actual state of affairs with respect to current goals and constraints must be evaluated. This analytical process involves prediction, value judgement, possible reassessments and the actors' priority making when they consider choice among options and possible actions.

Component 3: Planning actions
Based on the state of affairs from evaluation and choice among possible solutions to the identified problems, a proper sequence of actions must be selected. This revolves around the process of planning and scheduling and involves the decisions of actors and work situations that will be engaged in the execution of a decided action.

These components do not reflect a linear sequence of decisions. The decision processes iterate through the evolution of an information need.

6. Empirical analysis of semantic structures – an example case

This part of the article illustrates how cognitive work analysis can be applied for analyzing the semantic structures of a work domain, through an example case of knowledge integration in a film research archive. The example case builds on results from field studies and cognitive work analysis of cross-cultural film research for the creation of a web-based collaboratory to support decision-making in production, assessment and integration of knowledge in the film domain (Keiper et al, 2002; Pejtersen and Albrechtsen, 2002; Albrechtsen, Pejtersen and Cleal, 2002). The field studies were carried out in three European film archives during 2000-2002. A team of domain analysts conducted the field studies. The field studies made use of participant observation, interviews, focus groups and workshops (Pejtersen et al, 2001). All collected data were recorded on tape and transcribed. The data were analyzed by use of the framework for cognitive work analysis.

An important finding of the study was that collaboration is at the core of research and mediation practice in the archives. It was observed that collaboration happens in proximity, whether it be in teams of collaborating indexers, or in stable patterns of communicative interaction amongst staff and archive users (Pejtersen et al, 2001). While the archives are based on different cultural and historical traditions of collection building and mediation, they share the goal of making visible the use potentials of the collections for a broad spectrum of target audiences. The archives deal with use potentials in different ways. A recurrent pattern is to either enroll users in acquisition and interpretation of materials in an archive, and/or enroll users in continual proximity in an archives' search activity. In both cases, the purpose of user enrollment is not only to facilitate access to and circulation of materials, but also to encourage their participation in production and integration of film knowledge. User enrollment in subject analysis in collaborative film indexing is explored by Albrechtsen, Pejtersen and Cleal (2002) and Pejtersen and Albrechtsen (2002), and a classification scheme based on means-ends modeling and analysis of decision processes is suggested as a new symbolic artefact to support the collaborating actors' integration of knowledge throughout all steps of indexing.

The following introduces a different case of collaborative integration of film knowledge, in terms of a prototypical task situation of collaborative information searching. The example is based on the analysis of the data gathered in the study of the three national film archives, introduced above (Pejtersen et al, 2001). The intention is to show how cognitive work analysis can be applied to reveal evolving semantic structures in the work domain. Section 6.1 introduces and explains a means-ends representation of the territory of work, in which the activity of collaborative information searching takes place. Section 6.2 introduces an example prototypical decision task in collaborative information searching, which is carried out within this territory of work. Section 6.3 presents the main recurrent patterns in the collaborative decision task. Based on these analyses, the need for a classification scheme is discussed in section 6.4. An identification of semantic structures of the evolving integration of knowledge in the collaborative decision task is given in section 6.5.

6.1 Means-ends analysis of the territory of work in film research archives

Figure 3 illustrates a simple means-ends representation of the territory of work for information services activity in the national archive:

MEANS ENDS LEVELS	PROPERTIES REPRESENTED
Goals	Contribute to preservation and mediation of national and international cultural film heritage; contribute to national and international research on films
Constraints	Lack of a comprehensive central register for locating external materials; opening hours; lack of film content information in archive's databases; limited funds for acquisition of materials
Priorities	To reach broad and diverse target group of users; research; efficiency in finding information and locating materials; production and distribution of documentaries about Austrian culture from the 1930s onwards.
Functions	User services; arrangement of retrospectives; external collaboration with institutions and persons; document national research through colloquia, seminars and publications
Processes	Communicate with users face to face and by phone and e-mail; communicate with journalists and film distributors; write articles; watch and analyze films; staff coordination of user requests; registration of researchers' and students' projects
Resources and physical configurations	Staff offices and spaces; users' workspaces; reading room; collections; films, photos, posters, videos, users (different categories; collaborating institutions; Internet, e-mail, telephone, fax; paper file with research and student projects

Figure 3: *Means-ends representation of the territory of work for information services in the national film archive*

The archive has the overall *goal* (level 1) of contributing to national and international film research and to mediating national cultural heritage. The *constraints* (level 1) for mediation comprise the lack of a comprehensive central register for locating external materials and limited funds for acquisition of materials. The archive gives *priority* (level 2) to enrolling users in proximity for integration of knowledge, rather than, for example, to integration of knowledge through a dedication to comprehensive collection building. An additional priority is production and distribution of documentaries on video to the public about Austrian culture. The archive's collaboration with domain experts as well as lay users is very important for identifying and gathering films and film clips to produce the documentaries. Both priorities are linked to the overall goal (level 1) of contributing to national and international film research. The *functions* (level 3) in the work domain to serve this priority comprise information services in proximity and continual arrangements of film retrospectives, lectures and seminars for the users. *Processes* (level 4) of information services embrace, for example, face-to-face meetings and continual follow up contact on information needs amongst users and staff, maintenance of a paper file with descriptions of users' long term research or study projects, and acquisition, cataloguing and indexing of materials donated by users. The *physical resources* (level 5) that support these processes comprise an open archive environment where the users can browse collections' material resources, use the archive's computer-based information systems to access databases and the Internet, and where the users can go visit the staff in an informal manner during opening hours. The physical resources also comprise collection materials, computers and staff.

The *means-ends analysis* of the archive's territory of work reveals that the staff and their professional networking, locally and externally, are crucial resources for integration of knowledge. The means-ends analysis also discloses that the archive's internal constraints of limited funds for acquisition of materials impacts local regulations of work. Because the archive is not obliged to hold all national films and film-related materials, little priority is being given to comprehensive registration of films and film-related materials, which can function as an ordering system for horizontal information flow amongst the actors, staff and users.

6.2 Prototypical collaborative task situation

In cognitive work analysis, means-ends analysis of work domains is applied to capture the structure of the territory of work. The corresponding means-ends representation stands for the context in which work activity takes place. Activities are addressed through analysis of prototypical task situations. Task situations are directed to solving a particular work problem within the territory of work. As an analytical unit, a task situation is dealt with in terms of *what* the actors do, *how* they do it, and what *actors* are involved in decisions to solve the problem at hand, and how they *concert* their activities with one another (see, e.g., Rasmussen, Pejtersen and Goodstein, 1994; Vicente, 1999). The below description of a prototypical task situation in a film research archive is an example taken from the study of the three national national archives (Pejtersen et al, 2001). It introduces a prototypical task situation of collaborative information seeking within the national archive, whose means and ends were analyzed in section 6.1.

Description of a collaborative task situation: A university student of women's studies visits a film research archive to find materials and seek inspiration for an essay on socio-political conditions for women's lives in Austria during the 1940s. He is especially interested in how national feelings and women's values are represented in films from this period. The student is a newcomer to film studies where the essay is going to be submitted for exams. His education background is in literary studies. During his literary studies, he specialized in socio-cultural perspectives of gender and became inspired to work with critical discourse theory of literature, including Kristeva's notion of intertextuality. The new research area of socio-cultural perspective of gender is presently gaining interest within the academic curriculum and research of film studies in his country. Yet so far, the knowledge production is fragmented, with a high degree of diversity in concepts and terminology and research paradigms. The associated research area is characterized by a high degree of strategic dependence between experts, who are in contact in informal professional networking in order to move the field forward; there are no journals or textbooks dedicated to the field. In addition to this interdependence in the research community, students and researchers are dependent on expert intermediaries of collections, whose insights into different kinds of media is important to inspire the research. The student's supervisor has encouraged him to visit the film archive and also hinted what staff he might want to talk with in the beginning of his exploration of film knowledge. In other words, the student's research problem is formulated within a research area that is characterized by a high degree of strategic uncertainty (Whitley, 1989). The high degree of strategic task uncertainty in the student's project implies that it is difficult for the student to formulate an explicit information need and a search request when he meets up with the staff member of the archive. The student introduces his project to the staff member, and they create a description of his project in the archive's paper file of research and student projects. The staff member suggests an initial browsing of the collection. They browse the collection together during their first encounter.

The browsing activity yields some exemplars of films and film-related materials, which the student analyzes. At a later visit to the archive, the student talks with another staff member. The student now has a clearer picture of what he is looking for. The staff member, who has heard about the student project from her colleague during an informal staff meeting, listens to the student's ideas and insights. These ideas and insights are important for the archive's current emphasis on building up a more comprehensive network and collection to support knowledge production and exploration for the new research field. The staff member's background is in drama studies, and so, she has some background in text analysis, but not from a gender studies perspective nor from a critical hermeneutic perspective. From the outset, then, diverse and apparently incongruent perspectives characterize their communication. The staff member tries to translate some of the student's need formulations into search strategies. One strategy is to proceed from exemplars that the student found relevant for the problem and discuss possible implications of search results. Another strategy is to negotiate dimensions and properties of the student's information need.

6.3 Recurrent patterns in the decision task

Using the template for decision processes introduced in section 5.2, the collaborative task situation described above, can be analyzed into the following components:

Component 1: Situation analysis
The student and staff member exchange perspectives and conceptualizations about the student's project.

Decision analysis: Oral communication is the main medium for exchange of perspectives, and for the actors' joint decisions about evaluation and re-evaluation of the situation.

Component 2: Evaluation of options
Decision processes: The student screens some films and reads materials in the archive and discusses his assessments with staff members. The student and staff member decide on what main dimensions and properties are most important to resolve the student's information need, e.g., availability of original materials like films (fragments, descriptions, full-length films) and/or accessibility to literature about film directors' affiliation with particular paradigms and values.

Decision analysis: Evaluation of the state of affairs throughout the search is primarily dependent on screenings and readings of materials, constrained by the archive's opening hours.

Component 3: Planning actions
Decision processes: The staff member suggests browsing of the collection. Planning of actions is constrained by the lack of explicit information corresponding to the search criteria that the actors negotiate.

Decision analysis: Planning of actions is mostly dependent on browsing of the collection, but there is a need for the actors to define explicit dimensions of the information need. This can, for instance, be seen in the communication about the most important dimensions negotiated for the information need: the theme and plot of films and originators' affiliation with particular socio-cultural paradigms.

6.4 The need for a classification scheme

The cognitive work analysis of the example situation gives rise to a number of considerations for how to improve the possibilities for collaborative integration of knowledge in the archive.

Means and ends: The goals, constraints and priorities, levels 1-2 of the means ends representation in figure 3, constitute the overall possibilities and limitations for the student to gain the necessary material for his essay within this specific archive. Because the archive is not obliged to hold all films and film-related materials produced in the country, the student cannot find all relevant materials at the archive. Hence, many user requests to the archive involve inter-lending and ongoing networking by staff with other national archives. This is one background for the policy (priority) of extensive professional networking and continual education for the staff. Because the archive does not give priority to indexing all materials in the collection (function, level 3), the searches (processes, level 4) cannot be solely carried out in in-house databases and catalogues, but must involve searching in external databases as well as interaction with knowledgeable staff as information resources. Because there is no classification scheme available for browsing topics of the collection and for formulating search criteria, the staff and users have no available representation of possible orderings of the collection to refer to in their communication.

Semantic support: Obviously, subject access to materials through keywords would contribute to improving collaborative knowledge integration during all decision processes in information searching. However, the current keywords in the archive's databases and genre lists do not support exchange and integration of perspectives in the decision process of situation analysis in a collaborative task situation of information searching. Presently, there exist very few classification schemes for the film domain (cf. Rasmussen, 1997; Turner, 1994; O'Connor, 1985). The structures and contents of the existing schemes address the concepts and categories of film research from a scholarly and educational point of view. The films potential for cultural and/or emotional experience are rarely made explicit in the classification schemes through pertinent concepts. A recent German project on film documentation, Amphore, has addressed thesaurus building for indexing of film sequences (Süllow, 1996). However, Amphore's film indexing addresses the factual contents of the action taking place in film sequences and the objects or humans appearing in the films, not the films' or sequences' subject content, from a cultural or an emotional experience perspective.

Semantic multiplicity: Collaborative knowledge integration in the example is bounded by dialogue and negotiations amongst actors, which concern the higher means-ends levels of goals, constraints and priorities. This involves not only the higher means-ends levels of the archive's domain, but also the higher means-ends levels of the actors' domains. For instance, the goals of the student's domain (academic education in film studies) would comprise contribution to research, and the internal constraints, regulating the curriculum and hence his studies, could be particular research paradigms and research methods. Likewise, as shown in the means-ends analysis of the

archive (figure 3), some of the staff member's goals could be in alignment with the student's goals, i.e. to contribute to research, but the constraints, priorities, functions, processes and physical properties would be different. Collaborative integration of knowledge amongst actors from different domains proceeds as confrontation, negotiation and translation of perspectives, directed to solving the problem at hand, in order to get the work done.

6.5 Towards overall design of a classification scheme based on an evolving semantic structure

In the prototypical task situation of collaborative information searching in the film archive, the actors' knowledge is not merely reflected in the available means and ends in a macro-social perspective. It is equally reflected in the dynamics of collaborative activities, that is, in the actors' ongoing experience and activity. The empirical analysis of the actors' decision tasks can be taken to a systematic representation of the information that is needed to fulfil a task successfully, in this case an information retrieval task.

The properties that the student and staff member formulate together are illustrated in figure 4:

1. A film's promotion of particular understandings of gender roles and liberation versus tradition. The film director's explicit or implicit affiliation with particular socio-cultural values. Censorship.
2. The plot of a film; the heroes and villains; the ending; the socio-cultural setting of the plot, including place and time; the theme of the film.
3. A film director's narrative techniques, including inter-textual elements, like allusions to other films, myths and texts or intersecting plots.
4. The public reception of the film; contributions by film critics; the film's national or international impact; the career and life of one or two main characters in a film, i.e. how the 'embodiment' of the plot contributes to the message of the film.
5. A film's version, i.e. exists in full or as a fragment; a film's availability or the accessibility of film-related materials within the constraints of the student's time to write and submit the essay.

Figure 4: *The semantic structure of a studen's information need*

The list of properties in the student's information needs above could be regarded as constituting five dimensions of the information need, or, in cognitive work analysis terms, the properties of the semantic territory that the student and staff member explore together. The properties of these dimensions are interrelated, and each property is important for decisions about the search. If films or film-related materials are not available within the constraints of the student's deadline, then the student may decide to ask for a short description or abstract of the materials. If the career of a key actor has reflected leaps in the kinds of characters that an actor has embodied in films, then that aspect may be relevant, but not crucial for the essay. Findings of intertextuality in a film can ease the student's formulation of a methodology for the essay, due to his background in studies of Kristeva's theory. The dimension of subject content like theme and plot is important for finding as many films as possible from where the student can decide an empirical focus. The aspect of the film director's affiliation with particular views and paradigms about gender in society and culture is vital to the search. This is the highest interpretive value, as seen from the student's point of view and his background in critical hermeneutic literary theory.[1] The staff member contributes the idea of censorship history to reflect the degree of provocation of a film's overall message or elements, which may mirror the director's affiliation with paradigms or values vis-à-vis the socio-cultural values at a particular time.

Provided that the five dimensions of the properties in the student's information need (figure 4) can be regarded as prototypical semantic structures for collaborative construction of work content, they can inspire overall design of classification schemes, which can be used to support knowledge integration in collaborative indexing and searching of films. The example case also reveals explicit structures in the shape of ordering systems, which already support the collaborative practice of knowledge integration, such as the archive's register of research and student projects. Such ordering systems are important explicit sources for analyzing recurrent properties of information needs. This implies that initial needs analysis for design of a work-centred classification scheme must consider explicit as well as latent structures in order to capture the work domain semantics and the way these semantics are constructed, interpreted and integrated in order to solve the work problems at hand.

7. From the construction of a semantic structure of user needs to overall design

The above description and analysis of a prototypical task situation of collaborative integration of film knowledge in a national film research archive, illustrated the application of cognitive work analysis for identification of a semantic structure, reflecting the evolving content of work. The analysis focused on the work domain territory and decision processes, followed by an analysis and a preliminary sketch (figure 4) of the semantic territory within which an information need evolved. This analysis reflects the semantics of the actors' mutual process of exploration and integration of knowledge, which is necessary to make a common decision about an archive user's information need.

The example illustrated the following perspectives of cognitive work analysis for work centered design of classification schemes:

1. Actors' joint formulations of semantic structures of a common territory of work, in terms of the archive user's and staff members' iterative creation of search criteria;
2. Actors' joint formulation and reformulation of information needs in their negotiations about how to conceptualize the topic of the search as they shifted between different strategies, manifested in their exploration of materials;
3. Actors' joint oral formulations of a semantic territory of work, which constitutes a symbolic territory for navigation in knowledge and negotiations about the state of affairs. This semantic territory was derived from analysis of recurrent decision processes, shaping the evolution of the information need.

Design of classification schemes for work domains, based on empirical analysis of collaborative work is difficult. A key challenge for the analysis is that the semantic structures are evolving. We have argued that evolving semantic structures of work can be identified through cognitive work analysis of prototypical task situations, framed within a means-ends perspective. This argument does not imply that we regard empirical analysis as a stand-alone approach to the analysis of work domain semantics. The strength of empirical analysis is the capture and formulation of structures *evolving amongst the collaborating actors*, irrespective of their knowledge levels and ability for articulating what they know, and, just as importantly, do not know. As Cleal et al (2004) observe, from an empirical evaluation study on collaborative annotation of films in a cross-national film collaboratory, novice users do not yet possess integrated domain knowledge, nor do they have a tacit practice of scientific analysis and argumentation. Nonetheless, their need formulations and negotiations with experts are important elements in an analysis of semantic structures for design of information systems and classification schemes that can mediate the actors' mutual sense making and discussions. However, a precondition for the analysts to understand the evolution of semantic structures of work is the study of high-level interpretive values in the domain, such as policies for cultural mediation and scholarly research paradigms, in addition to more general domain studies (cf., e.g., Hjørland, 2002).

Furthermore, the prototypical task situation analyzed in this article represents only one type of collaborative task situation, from where work domain semantics can be identified. Work-centered design of classification schemes embraces an analysis of the full spectrum of prototypical task situations. For the film archive domain, this entails analysis of collaborative indexing, classification and information searching. Furthermore, work centered design considers the interdependencies between such recurrent collaborative task situations. That is, how their input and output are related to one another, and what kinds of social interactions exist within the social system of work to get the work done. An additional problem is how to transform identified semantic structures into a classification scheme. Transformation of semantic structures, identified through cognitive work analysis, corresponds to developing a model of a work centered classification scheme. For the creation of such a model, the analysis perspective shifts. In this analysis perspective, the identified semantic structures will constitute a new unit of analysis. The overall cycle of designing a work centered classification scheme by use of cognitive work analysis can be summarised as follows:

i) Empirical studies of knowledge integration in the work domain, guided by the framework of cognitive work analysis. The empirical studies should be accompanied by studies of high-level interpretive values influencing the work domain.
ii) Analysis of prototypical task situations of knowledge integration, by use of the means-ends abstraction hierarchy and templates for

analysis of decision processes, and identification of semantic territories for knowledge integration.

iii) Analysis of the identified properties of the semantic territories and transformation of the results of the analysis into multidimensional classificatory models.

Additionally, detailed analysis of the actors' needs for classificatory structures and concepts in individual and shared workspaces is necessary in order to assess what kinds of structures and concepts are suitable and how they should be displayed. Finally, the design cycle for work centered classification schemes comprises empirical evaluations in order to ensure that they are in alignment with the evolving semantics of their work content.

8. Conclusion and future work

This article has presented and exemplified a new approach to work centered design of classification schemes, based on cognitive work analysis. The approach introduces a new unit of analysis for the planning and overall design of classification schemes: collaborative task situations. The application of this unit of analysis for the planning and overall design of classification schemes was illustrated through an example case from a cognitive work analysis of three national film research archives. The taxonomy of cognitive work analysis was introduced in terms of the means-ends abstraction hierarchy and a simplified model for analyzing decision-making. It was shown how an application of these elements in the framework for cognitive work analysis supported identification of explicit, as well as latent, semantic structures of work content. The key challenge in work centered design is the dynamics of work domain semantics. The dynamics are not only reflected in evolving semantic structures, such as the structures evolving in existing orderings of knowledge like universal and domain-specific classification schemes, but they are equally reflected in the collaborative concept development in the work domain. In order for the analysts to understand such evolutionary semantics, empirical studies and analyses must iterate studies of high-level interpretive values influencing the work domain. Future work will address the complexity of collaborative concept development through field experiments in the film archive research domain. The intention is to refine the approach of work centered detailed design based on cognitive work analysis, and to identify its advantages and disadvantages vis-à-vis existing generic detailed design guidelines. Thus, the current research on classification schemes by use of framework for cognitive work analysis is not directed towards development of generic detailed design guidelines, but rather towards an exploration of the possibilities for grounding the entire design and evaluation cycle for classification schemes in the semantic dynamism of work domains.

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Note

1 The importance of representing high-level interpretive values in classification schemes for subject access to information has been addressed by, Hjørland, 1998; Hansson, 1999; Pejtersen, 1994; 1986 and Albrechtsen, 1992.

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