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Value and Uncertainty in Information Seeking

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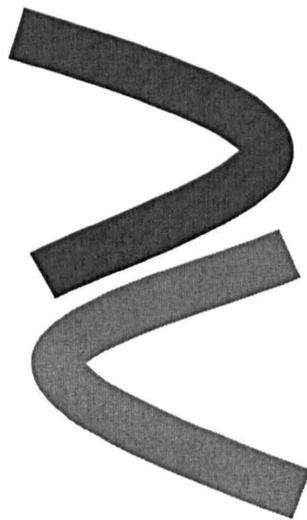
Value and Uncertainty in Information Seeking

Resolution of complex work tasks in an educational environment

PhD Thesis

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Abstract

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In the research model the information seeking process is seen as a dynamic development to reduce uncertainty or increase the value through four stages until the problem is solved. The results showed a surprising progress of the uncertainty stages. The hypothesis that the information seeking process reduces uncertainty through the four stages: 'problem recognition', 'problem definition', 'problem resolution' and 'solution statement' until the problem is solved can be rejected since there is no significant decrease in uncertainty level from stage 1 to 4. The hypothesis about the connection between the individual information seeker and the social and organizational environment was confirmed. A set of the most important core relevance criteria were applied. All kind of information source types were included.

The research developed a cognitive sociology model of information seeking. The research used a mixed methodology with a combination of qualitative and quantitative methods which complemented each other. Empirical data from 2002-06 in the social sciences and applied sciences domains were based on 14 case studies and 60 participants from a survey following the case study. The participants were dissertation students focusing on their dissertation from a UK research-led university in different departments and an IT university in Denmark.

Foreword

I thank the participants from University of Sheffield in different departments and the IT University of Copenhagen who contributed with the data in the qualitative part by online face-to-face form-based interviews (14 full-time graduate students from the University of Sheffield only) and in the quantitative part by submitting the comprehensive online questionnaire (60 full-time graduate students from both universities).

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1. Introduction

Information science incorporates the entire information life cycle from creation through dissemination, organizing, storage, and retrieval to the use of information by the individual or group in the organizational or community context. The fundamental question of the problem solving process during information seeking influences the databases we construct, the role of the human and interface intermediary, and the judgment and decision making of information sources. Does information science in an organizational context provide a *value* measured by the outcome of the information seeker's work task? The question may be addressed about the person's or organization's place and position in the field. The selection of evaluation criteria and the methodology to answer the question may be subject to an ongoing discussion. A *value* may be measured in terms of utility evaluated by approximate monetary value contribution over the expected useful life of the information management, information service, information system to the outcome of the work task. The monetary value may be assessed in comparison with the monetary value or expense of potential alternatives. In complex organizations and in complex problem solving tasks it may be impossible or difficult to systematically value the net gain or cost of the information management, information service, or information system for its stakeholders.

The definition of organizations has traditionally been understood as purposeful efforts to coordinate, influence, and control human behavior in order to reach some preferred outcome seen to reflect aspirations of rationality, effectiveness, and efficiency in the control of social life as well as of nature (Brunsson and Olsen, 1998, p. 14). The extended and revised interpretation of organizations is to observe the "larger variety of more or less stable patterns of interaction among individual and collective actors involving to varying degrees and in different combinations the elements of a Weberian organization" (p. 14). The ideal Weberian organization consists of (1) clear and definite boundaries, (2) central coordination system, (3) differentiated internally, (4) legitimacy, (5) the organization's characteristics determine what is achieved (6) malleable, and (7) part of a societal transformation (Weber, 1978).

From an evolutionary perspective of organizations Aldrich and Ruef (2006, p. 4-7) defines organizations as "(a) goal directed, (b) boundary-maintaining, and (c) socially constructed systems of human activity". They are (a) purposive systems whose members behave as if their organization has goals although individual members might personally feel indifferent toward those goals or even alienated. The goals may be explicit (mission statements, strategies), or implicit. (b) The organizations establish an authoritative process to enforce membership distinctions. Survival for the entity depends on its ability to control its boundaries. This view is moderated when nurturance, community, supportiveness, and interrelatedness are fused with individual responsibility. (c) Activity systems consist of bundled and interdependent role behaviors as routine set and activity bundles. The routines are inter-personal or interactions with non-humans (materials, machines, tools). The division of labor between activities leads to role and functional differentiation which is dynamic depending upon organizational growth and size. The internal structures (a-b) affect the meaning and satisfaction of individual participants by allocating power and job characteristics differently. The control structures that shape the way participants are directed, evaluated, and rewarded are constrained and may conflict with the participants' external social roles. Organizations depends on interchanges with their environment (institutions, culture, IT) to accomplish their work tasks.

The present research attempts to address the question independently of a particular economical or organizational interest by applying the concept of usefulness of information sources in the information seeking process to solve work tasks in a reality setting.

The aim of the research is to integrate the separated elements of empirical and theoretical knowledge about information seeking into a cognitive sociology model comprising the choices made, the search methods applied, the priorities made as well as the entire range of information sources available to the information seeker in his endeavor to fulfill the work task. The problem of separated elements of empirical and theoretical knowledge has, among others, been stressed by Chang and Rice, 1993; Hert, 1997; White and Wang, 1997; Ford, 1999; Vakkari, 1999; Vakkari and Järvelin, 2005 and Wilson, 1999. No integrated framework for cognitive information retrieval has until now existed according to Spink and Cole (2005, p. 233). This integration will provide a more comprehensive understanding of both searching and seeking information in a broad context of human information behavior. Case (2007, p. 314) finds the present field of 'information behavior' agreeing on the dynamic, personal, and context-dependent nature of the matter but lacks agreement of theories and methodologies when concepts are developed from many disciplines (sociology, psychology, communication, organizational behavior, and computer science). The history of the field shows the knowledge scattered over a broad range of domains and applications (Hahn and Buckland, 1998).

The economic pressure for organizations to be competitive in a highly international knowledge-driven market may force an integration of information seeking to enhance the efficiency of knowledge management (Choo, 2005). If the coordination and flow of knowledge in the organization is flawed or overlapping between staff, management and the various internal and external management information systems, the effectiveness and efficiency will decrease. If the search tactics and navigation of the people in the networked organization are harnessing the overall knowledge of the organization and are aimed towards the strategic management goals, the information seeking concept will under optimal market conditions be closer integrated. The optimal market situation may be only an ideal where there is equilibrium of competition and a sufficient supply/demand of well qualified labor for the organizations.

Marchand, Kettinger & Rollins (2001) have empirically proven 'information orientation' from a random sample of 376 companies with a total of 1009 senior managers in multiple industries, varying company sizes, levels of business performance, and years of existence. The managers represented 26 countries (excluding Japan) and 25 industry sectors (p. 257-258). (1) information behaviors and values, (2) information management practices, and (3) IT practices are 'key information capabilities' defining the strategic management concept information orientation.

The need for an integrated view of information seeking in organizations, whether profit or non-profit based, leads to the key problem of the present research based on determining the social mechanisms:

Beliefs: How information sources contribute to the actor's work task (measured by information sources and relevance criteria).

The relation between the individual actor and the social or organizational environment.

Falsification of the hypothesis that problem resolution proceeds in stages by reducing uncertainty or increasing the value at each stage until a resolution of the problem is reached.

A key factor in the development of a cognitive sociology viewpoint is the connection between the individual information seeker *and* the social or institutional environment during the process of problem solving.

The information seeking process is seen as a dynamic development to reduce uncertainty through four stages until the problem is solved (Wilson, 1999):

1. Problem Recognition: Kind of problem.
2. Problem Definition: Nature of the problem.
3. Problem Resolution: Finding an answer to the problem.
4. Solution Statement: An answer to the problem or how to deal with the problem.

If uncertainty fails to be resolved at any one stage it may result in a feedback loop to a previous stage for further resolution. The problem-solving process is seen as an iterative development.

The information sources comprise the entire range of sources used by the information seeker. They may be among those listed below:

1. Information sources required as part of the norms in the knowledge community.
2. Information sources proposed by advisers in connection with the work task.
3. Homepages found by the information seeker on the internet.
4. Public databases: Bibliographic, full text, numeric, and directories or dictionaries.
5. Public available printed directories and dictionaries.
6. Personal information sources in the investigated organizations.
7. Written information sources originating from the investigated organizations.

2. Information seeking

The cognitive, sociological, and domain-analytical approaches in information science are described and compared below.

2.1 Cognitive models and cognitive sociology

A stage-driven cognitive model of the information search process was developed by Kuhlthau (1993, 2004, p. 193-194) and divided in 6 stages characterized by 3 aspects: Affective (feelings), cognitive (thoughts) and physical (actions). The 6 stages:

1. Initiation: Aware of a lack of knowledge or understanding. Recognize a need for information. Contemplating the problem, comprehending the task, and relating the problem via prior experience and knowledge.
2. Selection: Identify and select the general topic to be investigated or the approach to be pursued. Weighting prospective topics against the criteria of personal interest, assignment requirements, information available, and time allotted. The outcome of

each possible choice is predicted, and the topic or approach judged to have the greatest potential for success is selected.

3. Exploration: Investigate information on the general topic to extend personal understanding. Becoming oriented and sufficiently informed about the topic to form a focus or a personal point of view. Inability to express precisely what information is needed makes communication between the user and the system awkward.
4. Formulation: Turning point in the search process when feelings or uncertainty diminish and confidence increases. Form a focus from the information encountered. Identifying and selecting ideas and forming a focused perspective on the topic. The topic becomes more personalized at this stage if construction is taking place.
5. Collection: Gather information related to the focused topic. Defining, extending, and supporting the focus.
6. Presentation: Complete the search and prepare presentation of the findings. Culmination of the search with a personalized synthesis of the topic or problem.

Kuhlthau (2004, p. 200) summarizes the process through the stages: "Uncertainty and anxiety can be expected in the early stages of the process. The affective symptoms of uncertainty, confusion, and frustration are associated with value, unclear thoughts about a topic or question. As knowledge states shifts to more clearly focused thoughts, a parallel shift occurs in feelings of increased confidence, uncertainty due to a lack of understanding, a gap in meaning, or a limited construct initiates the process of information seeking".

Spink (1996) has developed a model of multiple search sessions and Ingwersen and Borlund (2000) has built a situational and cognitive model of the search process.

In order to catch the development of the various information problems of the users over time it will be necessary to follow the iteration (new searches) and the interaction during these searches. These activities will be viewed in relation to the stage of the information seeking process.

Research in information seeking and information retrieval provide results which could be used as elements in pursuit of a deeper understanding of information actions and information seeking in general. Integrating results from both fields we are able to create a more holistic view of the search process and its different stages (Vakkari, 1999, p. 834).

The theoretical basis of information use is at an early stage, but is improved by a qualitative study by White and Wang (1997). It deals with citation behavior, in particular with the reasons of academic users for using documents retrieved from bibliographical databases in their final projects.

The theoretical model of the present research seeks to balance between the cognitive theories, which are highly individual oriented, and the discourse or sociology theories, which are highly focused on the domains, institutions, and group structures.

The social aspects of cognition may show that we not only think as individuals and as human beings in general, but also as social beings and products of particular social and institutional environments that affect the way we cognitively interact with the world (Zerubavel, 1997). The paradigms of cognitive viewpoints and discourse communities are conflicting. The application of a cognitive sociology to information seeking is pursued in the present research. The process of cognitive socialization lets us be part of a social inter-subjective world. Becoming social implies learning not only how to act but also how to think in a social manner. As we become socialized and learn to see the world through the 'mental lenses' of particular thought communities, we come to assign objects with the same meaning that they have for others around us, to both ignore and remember the same

objects that they do. Information seeking is an integrated part of the socialization and process of learning. The present research among social science and applied natural science master students may show how the connection is between the individual information seeker and the social or institutional environment.

Cognition is inherent of naturally, logically, and conventional functions. The theoretical balance must be between sociological science about the common social experience and the cognitive science about perception, information processing and knowledge structures (Cummins and Cummins, 2000). Cognitive psychology has developed into a more social integrated approach (Fiske and Taylor, 2007) to a broader understanding.

The recent development of the cognitive framework in information science is integrating information seeking and retrieval in context. The elements work tasks (real and simulated), query types, and information retrieval techniques are incorporated. All kinds of document representations may be part of the information space. The human-computer interaction and relevance feedback and evaluation are considered. Both individual and social behavior are considered for users and their information use. The users' situation is incorporated at the information retrieval stage and information use stage (Ingwersen and Järvelin, 2005).

Cognitive science had traditionally focused on information and humans in a rather individual approach and without emphasis on the meaning or content of the information. Bruner (1990, p. 12-13) argues that it is "man's participation in culture and the realization of his mental powers through culture that make it impossible to construct a human psychology on the basis of the individual one (...) To treat the world as an indifferent flow of information to be processed by individuals each on his or her own term is to lose sight of how individuals are formed and how they function".

The cognitive viewpoint is severely criticized by the domain-analytical approach. Hjørland (2002, p. 450) argues that the cognitive viewpoint has "neglected the social, cultural and historical nature of cognitive processes" and should be "more reflective and meta-oriented and demonstrate gaps and uncertainties in knowledge to users".

Interdisciplinary domains imply a more complex information seeking pattern. According to Foster (2004, p. 230) interdisciplinary is defined in an academic context as topics covered by "single researchers where the primary knowledge domain is either clearly focused and related to one or more other knowledge domains or appears as a composition or hybrid subject with no single domain focus". The results of the interdisciplinary information seeking are a variety of approaches, flexible, and within changing contexts. The information seeking is cumulative, reiterative, holistic, and contextual. The problem solving process was mainly non-linear in contrast to a progressing stage model (ibid, p. 235). The nature of the work tasks are biased towards the less clearly defined work tasks and without short term fixed commercial and production related purposes.

What is a domain? It is a body of knowledge that identifies and interprets a class of phenomena assumed to share certain properties and to be of a distinct and general type. A domain functions as a stable response to a set of recurring and complex problems faced by the organism. This response involves difficult-to-access perceptual, encoding, retrieval, and inferential processes dedicated to that solution (Hirschfeld and Gelman, 1994, p. 21).

Domains partition the world by identifying phenomena belonging to a single general kind. Domain competence systematically links recognized kinds to restricted classes of

properties. A cognitive domain is a class of phenomena that share among themselves, but not with other kinds, a number of relevant properties. The above mentioned authors admit that there is 'considerable variation' across domains in how flexible these connections are. Types of domains:

- The core knowledge within a domain is difficult or impossible to reach truth or consensus about (for example the humanistic fields of art aesthetics in paintings, poetry, and music).
- Historical development and speed of knowledge growth: The domain is young and immature or, otherwise, a well-established domain with authoritative institutions with traditions and recognized founders. If the speed of knowledge growth is high, the possibility of confusion and lack of comprehensiveness increases. The influence of paradigmatic developments and conflicts in science is well-described in Kuhn (1996).
- The domain is a conglomerate of different fields of knowledge. The multi-disciplinary development and approach results in a mixture of interpretations and paradigms. Information science is an example of a multi-disciplinary field.

Even if a domain skill is unevenly distributed within a population, it must be a solution to a repeatedly encountered problem. Some domain skills may appear to be closely tied to differences in the learning environment, even if the underlying domain competence does not depend on environmental conditions.

Domain operations generally involve focused, constrained, and involuntary perceptual, conceptual, or inferential processes (Hirschfeld and Gelman, 1994, p. 22-23).

The conceptual change which may take place during information seeking is often left unexplained. The conceptual change is captured empirically and theoretically in the application of the information need, the query formulation/query modification, or user relevance assessment. But where does this conceptual change come from? Human reasoners go beyond the principles at the core of their initial systems of knowledge. Reasoners do this, in part, by constructing mapping across different knowledge domains. Because the possibilities of mapping across different knowledge domains are vast, there is little reason to expect, a priori, that all adults in all cultures will have commensurable conceptions, even in those domains where humans are endowed with systems of knowledge whose principles both determine the entities of the domain and support reasoning about those entities (Spelke, 1994, abridged, p. 194).

The 'core knowledge' system is constructed by abstract representations of basic features of the world including objects and numerosities (humans and non-humans, infants and adults) (Spelke, 2000, p. 1240-1241). The limitations are (1) domain and (2) task specific aspects. The core systems for representing (1) objects and (2) approximate numerical magnitudes are the building blocks for later numerical and calculation skills. Spelke (2000) argues that our prolific tool construction and use depends on the core systems from infants (humans and non-human primates) by systems for representing (1) objects and representing (2) persons and their goal-directed and intentional actions. The human ability to navigate flexibly originates from the (1) core system of representing objects and a (2) core system of representing geometry of spatial layout. By combining representations from these systems, human children may not only, as other animals do, maintain their sense of orientation in a geocentric representation of the permanent environment, but in more flexible ways that

allow us to get from place to place “even when our sense of orientation is lost or when we find ourselves in novel surroundings. Humans (children and adults) may gain new abilities not by creating those abilities out of ‘whole cloth’ but by bringing together building-block representational systems that have existed since infancy” (p. 1241).

The core system ‘geometry of spatial layout’ can be extended to virtual spaces, for example information architectures applied in navigation structures, concept mapping, and decision trees.

In information science it is very sparse with empirical documentation of the domain analytical theory’s importance. How much influence has the domain or discourse communities in information seeking compared with individual knowledge structures and processes? The important question must be answered with a balanced research approach. If you only focus in the research model and design on those empirical data which can be interpreted to support your predefined hypotheses (i.e. pure domain factors or pure individual cognitive factors), then the conclusions are self-confirming prophecies.

The cognitive viewpoint in information science has until recently focused mainly on IR including artificial intelligence, user interface, and automatic relevance mechanisms. The development in information use is still at its early stage.

It is important to investigate the cognitive diversity by members of different thought communities. The results of relevance research show a huge variation in the user assessments under a wide range of environments and conditions. The diversity of user assessments in information seeking must incorporate sociological factors as well as pure cognitive factors to better understand the users’ reasons, attitudes, and behavior.

The information seeking takes place in a context which includes an institution or a network of institutions with varying degrees of formal rules and norms.

Institutionalization occurs whenever there is a reciprocal typification of habitualized actions by types of actors. There is reciprocity of institutional typifications and the typicality of not only the actions but also the actors in the institutions. The typifications of habitualized actions that constitute institutions are always shared ones. They are available to all members of the particular group in question, and the institution itself typifies individual actors as well as individual actions. The institution posits that actions of type X will be performed by actors of type X (Berger and Luckmann, 1966, abridged, p. 72). The reciprocal typification is explained shortly: As A and B interact in whatever manner, typifications will be produced quite quickly. A watches B perform. He attributes motives to B’s actions and, seeing the actions recur, typifies the motives as recurrent. As B goes on performing, A is soon able to say to himself, “Aha, there he goes again”. At the same time, A may assume that B is doing the same thing with regard to him. From the beginning, both A and B assume this reciprocity of typification. In the course of their interaction these typifications will be expressed in specific patterns of conduct. That is, A and B will begin to play roles vis-à-vis each other. This will occur even if each continues to perform actions different from those of the other. The possibility of taking the other will appear with regard to the same actions performed by both (ibid., abridged, p. 74).

Institutions further imply historicity and control. Reciprocal typifications of actions are built up in the course of a shared history. They cannot be created instantaneously. Institutions always have a history of which they are products. It is impossible to understand an institution adequately without an understanding of the historical process in which it was produced. Institutions also, by the very fact of their existence, control human conduct by

setting up predefined patterns of conduct, which channel it in one direction as against the many other directions that would theoretically be possible. It is important to stress that this controlling character is inherent in institutionalization as such, prior to or apart from any mechanisms of sanctions specifically set up to support an institution. These mechanisms (the sum of which constitute what is generally called a system of social control) do (...) exist in many institutions and in all the agglomerations of institutions that we call societies. Their controlling efficacy however, is of a secondary or supplementary kind (...). The primary social control is given in the existence of an institution as such (ibid., abridged, p. 72-73).

The scope of institutionalization depends on the generality of the relevance structures. If many or most relevance structures in a society are generally shared, the scope of institutionalization will be wide. If only few relevance structures are generally shared, the scope of institutionalization will be narrow. In the latter case, it is the possibility that institutional order will be highly fragmented as certain relevance structures are shared by groups within the society but not by the society as a whole (ibid., abridged, p. 97). In an educational system the educational and research policy and practice will decide the limits of cognitive control upon the faculty and students. In business the information policy and practice of the corporation, stakeholders, and the market will decide the limits of cognitive control of the employer's information seeking.

Social norms are similar to cognitive norms; we learn how to focus attention, frame our experience, generalize, and reason in a social appropriate manner. When we classify objects, we regard only some of the differences among them as significant and ignore others as negligible and therefore irrelevant. Which differences are considered significant is something we learn, and ignoring those that make no difference (Zerubavel, 1997, abridged, p. 13).

The institutional change of norms in educational systems is towards cognitive diversity and a rise of individuality and originality values. The cognitive diversity is in contrast to more traditional educational systems with emphasis on reproducing of a shared knowledge originating from their predecessors (Zerubavel, 1997, p. 21).

In information seeking within an educational environment it is therefore important to trace the evaluation of meaning and behavior of people. In the present research the focus is on the beliefs: How information sources contribute to the actor's work task (measured by information sources and relevance criteria). Furthermore, the focus is on the relation between the individual actor and the social or organizational environment. If the educational system (teachers/researchers) favors a high level of individualism and creativity the cognitive consensus within the educational system tends to be cognitive pluralism. If the educational system puts a strong emphasis on a core curriculum and reproduction of a unified view of the field, then the social and cognitive control is high and the limits are tight.

The integration of the sociological aspects in the process and outcome of information seeking is aimed at focusing on the mechanisms of the information seeking process during the problem solving stages for the actors. Hedström (2005) has developed an analytical framework for an explanatory social theory with 'actual mechanisms at work' (p. 3). The components of the social theory are as follows with key terms added in italics:

Mechanism: Real empirical entities and activities that bring about phenomena.

Social mechanism: Constellation of *entities* and activities that are *organized* in such a way that they *regularly* bring about a *particular type of outcome*.

Explanation of observed social phenomenon: The *social mechanism* by which such *phenomena* are *regularly* brought about and this entails a focus on the *social outcomes* that *interacting actors* are *likely* to bring about.

Explanatory foundation of sociological theories: *Action* and *interaction*.

Definition of *action*: What individuals do intentionally as distinct from mere behaviors. I act if and only if what I do is explainable by my *desires*, *beliefs* and *opportunities*.

Belief: Proposition about the world held to be true.

Desire: Wish or want.

Beliefs and desires are 'mental states' providing reasons for the action.

(abridged, p. 6).

Opportunities: Action alternatives available to the actor that exist independently of the actor's belief about them. The opportunities must be known to the actor and hence influence actions via the beliefs of the actor (abridged, p. 38-39).

Social interactions are at the 'core' of sociological theory because an individual's actions often cannot be explained unless they are related to the actions of others. This influence must be mediated via the mental states (*beliefs* or *desires*) or the action *opportunities* of the latter *actors* (abridged, p. 66).

Social outcomes, like other emergent phenomena, are difficult to anticipate because the outcome depends to such a high degree on how the individual parts are interrelated. Social outcomes cannot simply be read off from the properties of the individuals that generate them (abridged, p. 75).

The importance of theoretical social analysis: "Whether a set of mechanisms can account for the type of phenomena that we seek to explain. The relationship between the individual and the social is often precarious and easily altered by small changes in the logic of action or the structure of interaction. Empirically observed phenomena are often the joint outcome of many different processes operating in tandem. This means that we should always be alert to the possibility that small events external to the process focused upon can result in very different outcomes from those the theory predicts in the absence of such events" (p. 100).

"The model should be able to generate the social regularities being observed in a way that is consistent with what we know about real-world processes and this surely means that the model must be actor-based" (p. 111).

Methodology: "Quantitative research would be more useful for the development of explanatory theory if it focused directly on the *entities*, *activities*, and *relations* of the *social mechanisms* assumed to be operative instead of on correlations between different *social aggregates*".

The most appropriate statistical techniques when testing our theories, and we need to be as precise in formulating our theories as are the best sociologists in the statistical tradition when they specify and diagnose their statistical models (abridged, p. 33).

Theory development: "Estimate parameters of theoretically grounded models of individual's *opportunities*, *mental states*, and *actions*. By producing statistical evidence on how such *entities* and *activities* are influenced by various *individual* and *contextual* factors, including the *actions* and *mental states* of those with whom they *interact*, quantitative research could come to have a much more direct bearing on the development of explanatory theories of the *social*" (p. 113).

Hedström (2005) is not allowing qualitative methodologies a significant part in his methodology. Unfortunately, Hedström is not anticipating the importance for integrated theoretical and empirical development of qualitative data in the explorative stages of research which is the basis for later development of strong explanatory theories based on statistical validation. The complementary status of qualitative and quantitative methodology applied in the present research seeks to accommodate each methodology's strengths and weaknesses.

The applied formal analytical and methodological tools in the present cognitive sociology research model are based on the following adaption with Hedström's key terms in brackets:

Work task goals (desires): The work task goals are stated for each agent as

defined in the problem solving stages.

Final work (action): Outcome of the work task.

Relevance criteria (beliefs)

Information sources (opportunities)

2.2 Actor model

A model of the actor (user) or actor group is developed consisting of conceptual knowledge relating to the work tasks in the domains where the information seeking is taking place. The procedural knowledge is the methods of inferences and actions. In this research model they are called search methods and navigation for the qualitative part.

Information seeking in the social sciences has the human as information object in a sociological, anthropological, economical, organizational, or political dimension.

The work tasks in the domains where information seeking is taking place must be analyzed to find out how the actors organize their knowledge. The actors within a domain can be grouped in different categories according to the actual level of conceptual state of knowledge when going to search (Ingwersen and Järvelin, 2005). The conceptual levels in the information searching can be in a state of a 'compromised need' (Taylor, 1968, p. 182), i.e. the question as presented to the information system. The question is recast in anticipation of the organization of the particular database content and retrieval tools. The information problem can be more or less well defined (Belkin, Oddy, and Brooks, 1982). The conceptual structure may therefore be unstable.

Hert's (1997, p. 123-124) find that the user's situation may have too many dimensions which change too quickly to be accommodated in a model. Building these into systems will also require extensive resources. The situated nature of action also implies that the model would need to be updated continually over the course of an interaction.

The interactive and dynamic search process can be used to capture information of the actor during searching to enhance relevance feedback mechanism (Borlund, 2000).

2.3 Information objects

The definition of the information objects in the organization and in the corporation is particularly central to clarify and coordinate a common understanding and application of the information objects which are used to create, receive, and exchange the knowledge assets in the corporation. The understanding and application of what constitute an information object or knowledge object may be different depending on the domain, work group, and section of the corporation the employee is situated in, but a shared belief of what basic attributes the core business objects have are crucial for a unified corporate strategy and identity. A close, efficient, and strategic supply chain management and customer relationship management also assumes a shared understanding of the basic information objects from a technical and commercial perspective when used in the exchange of services and goods. A higher degree of relational closeness and strategic importance requires a higher agreement of the basic information objects.

We assume that the information object depends on conceptualization (cognition) or perception (sensory stimulus) of a human being. The information object is perceived as true by the actor. The actor can in a corporate context, for example, be an employer, employee, customer, supplier, government, or investor. The type of information object can consist of tangible, intangible, or a combination of both types. The information object can be either:

Atomized, i.e. the lowest level of micro cosmos at which the human being or a group of human beings at a particular stage of scientific development is able to measure objects with identifiable properties.

Aggregated, i.e. composite information objects. The composition can be of different types of information objects or similar types of information objects integrated or linked to each other physically, electronically, or purely on an intangible level (conceptual).

The definition about what constitutes a single data object, a single information object, and a knowledge object depends on a particular time frame of scientific development and the society's stage of what the human is able to measure and understand as member of a knowledge community. Different domains define their information objects differently depending on their theory, methodology, and applications. Inter-disciplinary domains need complex models of what constitutes a basic information object. The scalability and abstraction levels of the information object are illustrated in a simplified model (figure 1). The model start from the atomic level via at nanotechnological level to the level we can perceive by direct observation of our eyes.

The nanotechnology deals with particles from 10^{-9} to 10^{-7} m. They may have a random arrangement of the constituent atoms or molecules or the individual atomic or molecular units may be ordered into a regular, periodic crystalline structure which may not necessarily be the same as that which is observed in a much larger system. If crystalline, each nanoparticle may be either a single crystal or itself composed of a number of different crystalline regions or grains of differing crystallographic orientations giving rise to the presence of associated grain boundaries within the nanoparticle. Nanoparticles may be quasi-crystalline, the atoms being packed together in an icosahedral arrangement [geometric form with 20 equal sides] and showing non-crystalline symmetric characteristic. Such quasi-crystals are generally only stable at the nanometre, or at the most the micrometre scale. (Kelsall, Hamley, and Geoghegan, 2005, p. 2-4).

Measuring the information object from a financial and knowledge assets perspective is by assessing the 'fair value' of the asset and assessing the 'useful life' (International Accounting Standards Board, 2004). The useful life is the total period the corporation is expecting to gain revenue from the asset whatever sold or leased products. The useful life is assessed in each accounting year and depreciation is adjusted according to the current market conditions, taxation regulations, and contractual rules of the intangible assets.

The requirements for a data or information object to be calculated depend on the nature of the object, i.e. the ontological type of the object. Pure mental, spiritual, and artistic objects cannot meaningfully be computed, while objects which can be assigned an alpha-numerical objective value can be quantified by probabilistic methods and vector theoretical methods. The computations can be performed on either representations of real physical objects themselves or virtual objects, for example a hypothetical chemical compound (Leach and Gillet, 2003) or simulation of a mechanical device in a computer-generated model.

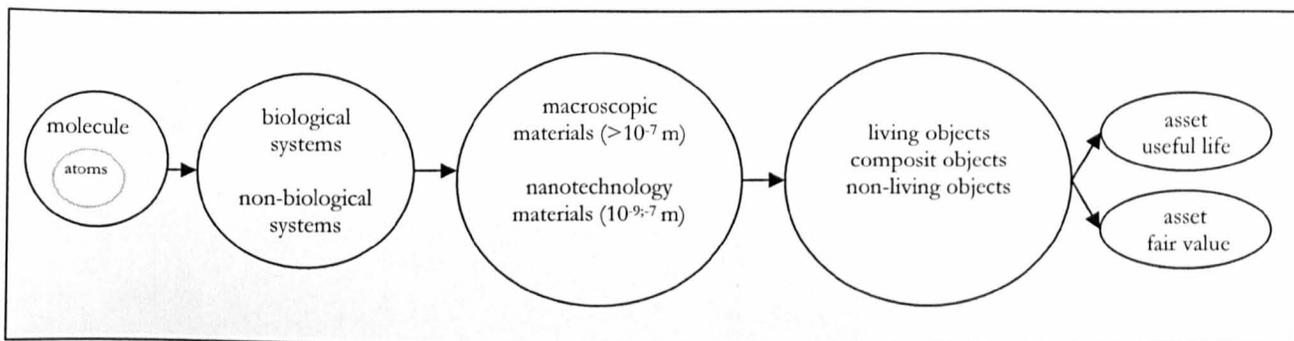


Figure 1: Scalability of information objects

The attributes of an information object also encompass the probability of gaining the projected revenue of the information objects which constitute the knowledge asset. The depreciation rate and period as measured in the asset's useful life determines the total revenue which the corporation expects and receives from their knowledge asset. The uncertainty criteria must be specified and quantified to the extent that the environment and market for the knowledge assets can be researched and monitored. The matrix below (table 2) outlines four main dimensions at a given time frame and financial quantity of the knowledge assets which the corporation is including in its annual intangible and tangible assets balance sheet.

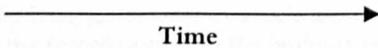
Investment uncertainty (Caballero and Pindyck, 1996) which the knowledge asset has been assigned as reflected in the relative quantity of risk abiding capital available and the interest rate level for the knowledge asset.

The concept of a competitive equilibrium in Cabellero and Pindyck (1996, p. 656-657) is uncertainty over market demand or average productivity which affects irreversible investment through the feedback of industry-wide capacity expansion and new entry on the distribution of prices. If the demand increases, existing corporations will expand or new corporations will enter until the market clears. It limits the amount that the price can increase under 'good' industry outcomes for the individual corporation. Each corporation takes price 'as given', but knows that the distribution of future prices is affected by the irreversibility of investment industry-wide, which leads it to 'raise the trigger point' for investment willingness. Idiosyncratic shocks which affect only an individual corporation to not 'induce entry' and should have less impact on the corporation's investment willingness. In the authors' theory the aggregate uncertainty increases the trigger point which results in a higher required rate of return. The model is validated by using investment and marginal profitability of capital at 20 2-digit US manufacturing industries and their 443 4-digit subsectors from 1958-1986.

Additional central factors affecting the uncertainty are market segment and position of the knowledge asset(s) in the industry. Assessment of the supply/demand projections will be included as well as macroeconomic factors internationally or nationally influencing the demand/supply for the industry.

The four dimensions of the knowledge asset's dimensions interact with each other (table 2). The exact interaction pattern is determined by the game of the firms in the industry assuming equilibrium. The market power, profitability, and size of a corporation determine the interest rate and risk abiding capital which they can invest for in knowledge assets.

Knowledge asset format	Investment uncertainty of knowledge assets
Market segment position demand/supply	Useful life value



Time

Table 2: knowledge asset dimensions

The definition of an information object only includes what is explicit. The information object may be tangible, intangible, or a combination thereof. The delivery of the knowledge asset may encompass tacit knowledge in a substantial degree which is typical for customer and supplier relationship management and craftsmanship. The nature of a skilled craftsmanship based on experience and application obtained via a master/apprentice relationship depends on a combination of tacit pragmatic knowledge and explicit contextual knowledge. The craftsman does not always need to explain and document his performance for every product or service element he delivers. The ‘learning by doing’ is obtained by a combination of the basic theory of the domain, technology, and mastering skill by practical typical work tasks. The ‘rules of thumb’, ‘intuition’, and ‘bodily movement’ and ‘situated knowledge’ is often dominated by tacit knowledge (Von Krogh, Ichijo, and Nonaka, 2000). Corporate and society’s norms and ethics embedded in the daily work practices are often tacit. Norms of a corporation can be explicit in mission statements and procedures but even the most explicit elaborate and linguistic precise descriptions of the moral and ethical values of a corporation still require tacit interpretation of each employee in the day-to-day decisions and actions.

The assumption of equilibrium in relation to the knowledge asset dimensions can be analyzed on different levels and relating to present conditions and future predictions. Machlup (1984, p. 251-252) defines the levels consisting of household, the corporation, the industry for a group of corporations, the market of supply and demand, the national economy, and asset portfolio equilibria (stock). The assumption of profit maximizing can be broadly defined as “selection of the action with the optimum distribution of potential outcomes according to the business’ outlook and preferences” (1984, p. 33).

Transaction economy models do not explain the importance of knowledge assets in corporations and all attributes of customer and supplier relationships. Simple transaction economy models need to be extended to encompass knowledge assets and corporate learning. Nooteboom’s (2004, p. 521) research emphasize innovation which cannot develop to a full commercial extend if all relations are reduced to contracts.

Furthermore, comprehensive and representative empirical research is required to test the extent of and under what conditions the corporate partnerships are (1) pure contractual or (2) pure non-contractual innovation partnerships. Any corporation is required to protect its intellectual property (the knowledge assets) to ensure they can gain the expected revenue and profit of their investment. The conditions of the two types of relationships (contractual and non-contractual) include outsourcing of non-strategic functions of a corporation.

The information objects can be represented in a record, which in accordance to the International Organization for Standardization (2001) about records management is

defined as “information created, received, and maintained as evidence and information by an organization or person, in pursuance of legal obligations or in the transaction of business” (p. 3). The key characteristics of a record are as follows:

“A record should correctly reflect what was communicated or decided or what action was taken. It should be able to support the needs of the business to which it relates and be used for accountability purposes”.

As well as the content, the record should contain, or be persistently linked to or associated with, the metadata necessary to document a transaction, as follows: a) The structure of a record, that is, its format and the relationships between the elements comprising the record, should remain intact. b) The business context in which the record was created, received and used should be apparent in the record (including the business process of which the transaction is part, the date and time of the transaction and the participants in the transaction). c) The links between documents, held separately but combining to make up a record, should be present. Records management policies, procedures and practices should lead to authoritative records which have the characteristics:

Authenticity: Can be proven: a) Be what it purports to be. b) Created or sent by the person purported to have created or sent it. c) Have been created or sent at the time purported.

To ensure the authenticity of records, organizations should implement and document policies and procedures which control the creation, receipt, transmission, maintenance, and disposition of records to ensure that records creators are authorized and identified and that records are protected against unauthorized addition, deletion, alteration, use, and concealment.

Reliability: Contents can be trusted as a full and accurate representation of the transactions, activities or facts to which they attest and can be depended upon in the course of subsequent transactions or activities. Records should be created at the time of the transaction or incident to which they relate, or soon afterwards, by individuals who have direct knowledge of the facts or by instruments routinely used within the business to conduct the transaction.

Integrity: Complete and unaltered. It is necessary that a record be protected against unauthorized alteration. Records management policies and procedures should specify what additions or annotations may be made to a record after it is created, under what circumstances additions or annotations may be authorized, and who is authorized to make them. Any authorized annotation, addition or deletion to a record should be explicitly indicated and traceable.

Useability: Can be located, retrieved, presented and interpreted. It should be capable of subsequent presentation as directly connected to the business activity or transaction that produced it. The contextual linkages of records should carry the information needed for an understanding of the transactions that created and used them. It should be possible to identify a record within the context of broader business activities and functions. The links between records that document a sequence of activities should be maintained (ibid, abridged, p. 7-8).

Tague-Sutcliffe (1995) summarizes the measurement of information which encompasses the context, authority, and truthfulness in an algorithm. The information may be manipulated or mediated by mechanical or electronic instruments. Tague-Sutcliffe's definition is limited to text but can be extended to numerical information for a more comprehensive understanding of information.

A source of messages X informs a receiver Y that P is the case
if there exists a set S of sentences, that is, a message, such that
X sends to Y in context I
Y receives and understands the sentences of S
P is the conglomerate proposition expressed by S in context I
X is in a position to know that P is the case.

I is the information provided to a user Y by S in context C if
there exists a record S such that
Y reads or otherwise perceives S in a context C
Y uses his or her conceptualizing capacity to understand S

I is the conceptual structure that Y understands by S
Y views context C, in general, as a source of true sentences

According to Tague-Sutcliffe (1995, p. 9-12) “information is an intangible that depends on the conceptualization and the understanding of a human being. Records contain words or pictures absolutely, but they contain information only relative to a user. The information is what the user understands by reading or otherwise cognitively processing the record. The information does not really have a separate existence external to the things that contain it or to the reader or listener who perceives it”.

2.4 Search methods

The search methods include the tactics and navigation applied to the selected information sources. The lexical definition of tactics is an “action or strategy carefully planned to achieve a specific end”.¹ The tactics include the type of search. The search type may be verification of a particular document by an author/title or a subject search. A subject search may also be a search for an author representing a subject in which the actor is interested. The prevailing mode of navigation will be examined whether browsing or systematic searching is preferred. Browsing is defined as an unstructured way of searching similar to the berry picking method proposed by Bates (1989). Systematic searching is defined as a conscious tactic, which follows a repeated pattern, procedure, or rule. Looking something up in the subject index is an example of systematic searching.

The coverage of the information space in information seeking may be divided in the focus of a single information system (i.e. a single database or a single library collection), a set of information systems (i.e. a database host or a restricted set of information objects limited by geography, physical formats, or institution), or the whole information space (the entire range of information sources).

Chang and Rice (1993, p. 258-262) define browsing in a broad and interdisciplinary way which enhances, perspectives and strengthens the application and validity of the theory. It is the process of exposing oneself to a resource space by scanning its content (objects and representations) and/or structure, possibly resulting in awareness of unexpected or new content or paths in that resource space. Browsing may be planned or unplanned, habitual or situational, serving to identify or select, familiarize or learn, assess, and monitor resources in an environment. Browsing is influenced or constrained by various factors and can have both positive and negative consequences. They propose a general model for browsing consisting of four major elements:

1. Context: Organization, interface, feedback, and economics.
2. Influences: The user behavior, motivation, cognition, and the resources searched.

¹ ‘tactic n.’ in: Soanes, Catherine (ed.); Stevenson, Angus (ed.) (2006). Concise Oxford English Dictionary (ed.) [online]. 11th ed. Oxford: Oxford University Press. www.oxfordreference.com

3. Process: Browsing is characterized by iterative movement in a scanning and examining activity.
4. Consequences: Due to the interdisciplinary nature of the analysis of Chang and Rice (1993) the outcome may be very broad ranging from producing work results of different levels to serendipity. The information seeking process may result in reduction or increase of uncertainty, i.e. disorientation or information overload.

A critical problem remains within the information seeking literature about the inherent nature of seeking. Any biological organism, especially the human being, is throughout its life purposeful. The division of information seeking goals with or without purpose is artificial. Every kind of information seeking or browsing has a purpose. Maybe it is not possible for the information seeker to explicitly explain what he or she is looking for, but people take part in knowledge communities within they continuously select and prioritize among the sensory and cognitive information in the world.

When we evaluate the well, ill-defined, or muddled information need we have to take into consideration the relativism of the conception; especially during the iterative and dynamic process of browsing in the whole information space. The dispositions of the information seeker in the knowledge communities he or she takes part in influence the interpretation of the goal and his or her choice of navigation in the information space.

2.5 Increase value and reduce uncertainty

The elusive concept of uncertainty has been approached from a variety of fields. The 'uncertainty' may be a central or only supportive character for the domain's theory and application. Within statistics the concept is of major significance in assessment of probability. The probability-approach is applied broadly within economics and decision-making. For example, the game theory applies the assessment of uncertainty for decision-making (Biswas, 1997) and for investment purposes (Dixit and Pindyck, 1994). In the economics of information, the perspective is on equilibrium where a market is based on information symmetries or asymmetries from the supply or demand side. Actors who can "evaluate their strategies more symmetrically by observing post-purchase information search more intensively" (Einav, 2005, p. 253) by playing an automatic betting game with a learning function. The observational regret is seen as a method for improved learning.

The significant international rise from the middle of the 1990s in risk management spanning a broad range of society from the public and private sector is closely coupled to the assessment of uncertainty. Power (2007, p. 5) defines the institutional and managerial distinction between uncertainty and risk between "events and issues which are expected to be treated within management systems as 'risks' and those which are not. Uncertainty is therefore transformed into risk when it becomes an object of management, regardless of the extent of information about probability". The focus of risk management is dealing with different types of risks: Economic, environmental, health, and safety. For example, the requirements for public listed companies in the European Union (European Union, 2007) and the US (Senate and House of Representatives of the United States of America in Congress, 2002) to provide a risk management assessment for public disclosure on a regular basis following the international financial accounting standards (IFRS or US GAAP).

From the sociological aspect, which is the most appropriate approach for information seeking, Fuchs (1992, abridged, p. 190-192) describes the theory of scientific organizations where task uncertainty is defined as the extent to which scientific problems are perceived as

complex and unpredictable. Task uncertainty is high when there are no standard and agreed-upon ways of dealing with a problem, and it is low when more routine problems can be solved by more predictable and generally accepted research techniques. Generally, task uncertainty is high whenever complex problems require innovative approaches, and when there is not a great deal of agreement over the appropriate ways of solving a problem. Conversely, task uncertainty is low whenever routine problems may be solved by standard approaches, and when there is not much controversy and disagreement over the right ways of doing research. One of the unanswered research questions, caused by lack of integration and systematic comparisons of variables, is if Fuchs' argument is right in the task uncertainty not primarily following from the intrinsic complexity of particular subject matters, but from "patterns of social organization of scientific fields". Fuchs' hypothesis is that task uncertainty follows from heterogeneity and change. The more heterogeneous a particular field, the more disagreement exists between the various schools and perspectives, and the less it can be claimed that any particular approach is superior to all the others. Task uncertainty is increased by competing schools and approaches debating the right ways of doing research. Conversely, a high degree of agreement and uniformity when there are generally accepted standards for doing research. Task uncertainty is higher in fields with high rates of change, no matter whether change occurs as accumulation, specialization, fragmentation, or migration. However, it can be argued that task uncertainty is lowest in fields with specialization as the dominant mode of change, for specialization requires only the expansion of established research practices into new problem areas, not the innovative modification or disintegration of paradigms themselves. In fields with high rates of innovation and accumulation, and in fields with fragmented disciplinary approaches, task uncertainty will be higher than in fields which sub-specialize on particular tasks while maintaining their overall paradigmatic integrity (Fuchs, 1992, abridged, p. 190). Fuchs describes the ways research is organized and findings are communicated as 'bureaucratisation of control'. There is 'interaction effect' between task uncertainty and coordination problems. The assumption is that research efforts will be coordinated bureaucratically only if task uncertainty is low. Standard methodologies, routine assessments of results, and regular research practices will coordinate activities only if the tasks involved are not too uncertain. These groups have a high 'group consciousness', a strong confidence in the value of 'scientific' doing and evaluating research. Such fields are perceived as very 'mature' for they produce 'scientific' and 'objective' knowledge. Conversely, under conditions of high task uncertainty, coordination problems will be solved more by informal adjustments and ad hoc mutual consolations. High task uncertainty implies that there are no rigid standards for doing proper research, that what counts as 'good science' is ambiguous and controversial, and that there are only a few routine solutions to problems. High task uncertainty is found in the innovative core areas in a field where science is 'science-in-the-making' rather than ready-made science. High task uncertainty is also found in fragmented fields with low overall disciplinary integration, for various approaches and schools compete over the right ways of doing research. Under these conditions scientific research activities will not be coordinated bureaucratically, but informally, i.e. contextual and situational negotiations (Fuchs, 1992, abridged, p. 191-192). The bureaucracy is present in every kind of professional organization and educational institution. The present research measure the bureaucratic impact indirectly through the control of the output by the problem-solvers, i.e. the participants' ability to pass the required work task.

Cognitive psychology approaches the uncertainty from a mainly individual perception. Hogarth (1987) has treated the concept from a judgment and decision making perspective. An organizational perspective is provided by Brunsson (2007). One of the heuristic biases judges during information seeking and evaluation is predicting simply by matching prediction to impression. They fail to take the uncertainty of the evidence into account.

The management of uncertainty for decision-making in organizations is viewed multi-dimensionally by Choo (2005, p. 247-248). "The ability of individuals in organizations to behave rationally is limited by their cognitive capacities, information constraints, and differences between personal values and organizational goals". "Decision makers satisfice rather than maximize. They follow rules and routines that simplify the decision-making process by reducing the need for search, problem solving, or choice. All decisions are about finding and choosing courses of action in order to attain goals. The difficulty of making a decision then depends on how clear the goals (goal uncertainty) are and how well we know about methods (procedural uncertainty) that can achieve the desired goals". The analytical models used may in principle be one or a combination of the following types: (1) Rational model where "goals and available alternatives are clear, the organization reduces the uncertainty of decision making by specifying decision premises, rules, and routines" or (2) process model where the decision-makers "identifies the phases and activities that form the structure of many strategic decision processes. The quality of a decision process depends on the way a decision is framed and the way alternatives are developed", or the (3) political model where "organizations respond to goal conflict in two generic ways. They behave as coalitions and they pursue procedural rationality".

Kuhlthau (1993, 2004) proposed an uncertainty principle as a basis for interaction into the process of learning from information enabling actors to move from uncertainty to understanding as stated in section 2.

Wilson (1999) developed a conceptual model of reducing uncertainty in information seeking. The information seeking process is seen as a dynamic development to reduce uncertainty through four stages until the problem is solved:

1. Problem Recognition: Kind of problem.
2. Problem Definition: Nature of the problem.
3. Problem Resolution: Finding an answer to the problem.
4. Solution Statement: Answer to problem or how to deal with the problem.

If uncertainty fails to be resolved at any one stage, it may result in a feedback loop to a previous stage for further resolution. The problem-solving process is seen as an iterative development.

Wilson et al. (2002) have implemented the concept of uncertainty with a mainly quantitative methodology. The information seekers (198 UK and US researchers) "can express the degree of uncertainty they have regarding the stages of the problem-solving process in which they are involved, and in relation to their assessment of the likelihood of information being available". There were significant differences in the relationship of uncertainty level and problem stage of information seeker and his knowledge of the domain investigated. When the information seeker "proceeds through the stages he will engage in specific information seeking acts to reduce uncertainty". The greater the knowledge of the domain, the less likely he is to express uncertainty, especially about

“problem identification”. There was no difference in the uncertainty level related to sex, age, or discipline (p. 712-713).

The norms of problem definition and resolution are a relation between the individual problem-solver and his social and organizational environment. The information seeking is not carried out in an empty space without influence from knowledge communities and the economical and physical constraints. The borders defined by the knowledge communities of what is an acceptable problem definition and the rules and norms of how to solve the problem is important to evaluate.

The probability of success or failure is fundamental in the problem-solving process. The information seeker evaluates the alternatives and tries under ideal assumptions to select the best or most optimal solution to the problem. The consequences of success or failure determine the level of risks (and uncertainty) the information seeker is ready to deal with.

2.6 Division of labor and work task

The work task from which the information problem is derived is dependent on the present state of the socio-economic development in the state wherein the people solving their work tasks takes place. The organization and methods to deal with the work task depends on the present division of labor in the generic levels encompassing the global, inter-state, single state, and community sphere. The different generic levels may interact dynamically with each other in a diversity of ways. The relations may be mutual on an equal or unequal basis depending on the power relations between the participants of the work tasks. The relations may vary in their closeness ranging from formalized contract-based agreements to informal loose networks without direct consequences and responsibilities for the involved people. The division of labor may occur on an impersonal abstract level between independent organizations, i.e. profit- and non-profit institutions. Alternatively, the division of labor may occur on a personal manner in team works, employer-employee, customer-company relationships, or subcontractor-contractor relationships (figure 3).

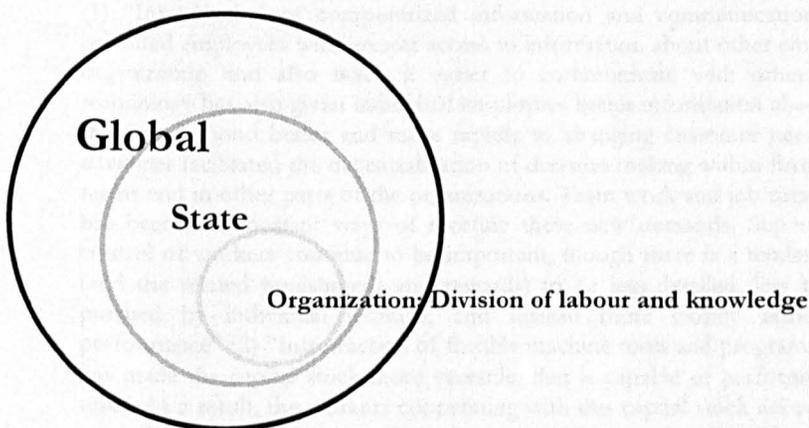


Figure 3: Division of labor

The division of labor has been systematically treated by Smith (1776) and is caused by “the very slow and gradual consequence of a certain propensity in human nature which has in view no such extensive utility; the propensity to truck, barter, and exchange one thing for another” (p. 25).

The division of labor is limited by the extent of the market (p. 31-36). A country’s wealth and its demographic characteristics must be considered when evaluating the division of labor. Since the last quarter of the 1700s the internationalization and industrialization has

revolutionized the extent and structure of the market. Vast improvements in infrastructure, communication, and transport both physically and electronically ease and remove borders between markets which previously hindered exchange of labor, goods, capital, and knowledge.

The capitalist nature of production was later developed by Marx (1887). The qualitative and quantitative difference of levels between the organizational and state level regarding the division of labor is analyzed by Marx. He differs from Smith in the understanding of the capitalistic character of production. The concept of equilibrium which was the ideal for Smith from a liberalism point of view and a constant dialectical matter for Marx.

The reorganizing of firms continues over time and at an exponential speed with the following central features:

- Increased role for team work and job rotation.
- Reduction in number of management levels.
- Continuous learning and development of complementary skills.
- Decentralization of responsibility within firms.
- Direct participation of employees in decision making on multiple fronts.

The restructuring process is widespread across countries, sectors (services and manufacturing), and firms within sectors (Gallie et al., 1998). The features have learning multiple tasks, blurring of occupational barriers, and the use of experience gained at one task to enhance performance at another task in common (Lindbeck and Snower, 2000, p. 354-355).

The interrelated forces of the reorganization process are summed up (Lindbeck and Snower (p. 355-357):

(1) "Introduction of computerized information and communications systems, which have provided employees with greater access to information about other employee's work within the organization and also made it easier to communicate with other. The new information technology has also given individual employees better information about customers, permitting them to respond better and more rapidly to changing customer needs. Not only have these advances facilitated the decentralization of decision making within firms; both within their own teams and in other parts of the organizations. Team work and job rotation, hence multitasking, has become important ways of meeting these new demands. Supervision and management control of workers continue to be important, though there is a tendency for such supervision (and the related punishment and rewards) to be less detailed, less tied to specific activities pursued by individual workers, and instead more closely associated with post facto performance" (2) "Introduction of flexible machine tools and programmable equipment, which has made the capital stock more versatile, that is capable of performing a wider spectrum of tasks. As a result, the workers cooperating with this capital stock are required to become more versatile as well. In the manufacturing sectors, this development has often reduced returns to scale, lowered setup and retooling costs, permitted shorter production cycles, and resulted in faster deliveries. This in turn, has enabled firms to give customers more individualized treatment. Moreover, greater interaction with customers often implies that employees need to exercise social, interactive skills in addition to fulfilling their formal occupational requirements".

(3) "Steady growth of human capital per worker, generated by education systems, vocational training programs, and on-the-job training. This growth has taken the form not only of 'capital deepening', in the sense that individual workers have improved their performance of particular skills; it has also involved substantial 'capital widening', that is, increased ability to acquire a variety of skills. This development, and especially the widening of human capital, is permitting firms to reorganize and integrate tasks along the new organizational lines".

(4) "Many workers have come to prefer jobs that permit the exercise of diverse skills. (...) Resent the monotonous, fragmented jobs of traditional organizations and to prefer more varied, multifaceted work".

The occupational barriers are breaking down and the theory, structure, and methods of domains are more interdisciplinary. "The traditional organizations required employees to have highly specialized skills, appropriate for standardized production processes (...) Workers are often given responsibilities spanning more than one of the traditional occupational groupings. Greater emphasis is now placed on continuous learning and skill development, all-round knowledge, the potential to acquire multiple skills, and the ability to learn how the experience gained from one skill enhances another skill. The new forms of work organization are commonly designed to facilitate such 'multitask learning' in order to exploit complementarities among tasks".

"The blurring of occupational barriers and the rise of multitask learning is closely associated with the decentralization of authority within firms. The traditional pyramidal structures in service and manufacturing organizations, in particular large ones, implied that authority flowed from senior executives, down through layers of middle management, to the workers in the various functional departments. This structure is increasingly giving way to flatter organizations in which customer-oriented teams are often given greater authority. Decision making has been moved closer to the people who have the relevant information, much of which is tacit knowledge among front-line workers. The decentralization of decision making often also takes the form of consultation or delegation, or both. (...) Decentralization of decision making often means that employees perform a wider variety of tasks within their firms than heretofore. For instance, employees often share tasks within tasks or combine a core job with other tasks, even sometimes including some managerial or consultative functions".

Therefore, one of knowledge management's key purposes is knowledge sharing. Building an organizational map of who knows what and the knowledge holder's various relations within and outside the organization.

The decentralization of decision making and learning across tasks is enhanced by the following three management tools:

Total Quality Management (TQM):

"Total quality management approach of an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society". The expression 'All its members' designates personnel in all departments and at all levels of the organizational structure. The strong and persistent leadership of top management and the education and training of all members of the organization are essential for the success of this approach. In total quality management, the concept of quality relates to the achievement of all managerial objectives. The concept 'benefits to society' implies, as needed, fulfillment of the requirements of society (International Organization for Standardization, 1994).

Just In Time Manufacturing (JIT):

"Philosophy of manufacturing based on planned elimination of all waste and continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product from design engineering to delivery and including all states of conversion from raw material onward. The primary elements of Just-in-Time are to have only the required inventory needed; to improve quality to zero defects; to reduce lead times by reducing setup times, queue lengths, and lot sizes; to incrementally revise the operations themselves; and to accomplish these things at minimum cost. In the broad sense, it applies to all forms of manufacturing – job shop, process, and repetitive – and to many service industries as well" (Association of Operations Management, 2008).

Lean production:

“Philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It involves identifying and elimination non-value-adding activities in design, production, supply chain management, and dealing with the customers. Lean producers employ teams of multiskilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes in potentially enormous variety” (Association of Operations Management, 2008).

These management tools do not necessarily enhance creativity and explorative information problem solving since they are focused on efficiency and effectiveness. Explorative oriented problem solving may lead to more or less fruitful results and long time loss or benefit for the organization depending of the success of the problem solving.

“Customer-oriented teams encourages the exploitation of complementarities among tasks, the sharing of tasks within teams, and the bringing of the decision-making power closer to the people who have the relevant information” ((Lindbeck and Snower, 2000, p. 357). The authors base their framework on a comparison between the benefits and limitations of two types of learning:

- **Intrataask:** Learning by doing. The more time a worker spends at a particular task, the more skillful he becomes at performing that task and thus the greater becomes his productivity from this activity.
- **Intertask:** Arises when a worker can use the information and skills acquired at one task to improve his performance at other tasks. Takes place through job rotation within and between teams of workers in production, management, marketing, and other units.

The organic or holistic oriented organizations with a rather flat structure and focus on decentralized decision-making, support of knowledge generation on all levels, and inter-task learning is in a dialectical relationship with the mechanical or machine bureaucratic oriented organizations (Taylor, 1911) with a rather hierarchical structure and focus on command-based decision making and task-specialization of workers.

The division of labor on a global level caused by international trade and resulting in increased wage dispersion (Lindbeck and Snower, 2000, p. 373):

(1) “enabled an increasing number of firms in the advanced industrialized countries to shift to products and production processes requiring holistic organization while they contract out the routine, assembly line work to other countries”. (2) “Increased wage dispersion is a result of technological change, education, and training”. (3) “specifies how changes in production and information technologies and how education and training may be expected to affect the dispersion of wages and employment opportunities in the context of the reorganization of work”. (4) “Within particular education, occupation, and job tenure groups are likely to vary considerable in terms of their social competence, judgment, and ability to perform multiple tasks. Thus in countries such as the United States and the United Kingdom, where real wages often respond flexible to changes in labor demands and supplies, the move from a Tayloristic organization of work to a holistic one may lead to widening wage dispersion of wages within these groups. By contrast, in several European countries where real wages are more rigid, the reorganization of firms may give rise to a widening dispersion of employment opportunities among these groups, for a given distribution of abilities”.

The understanding of work tasks in an organizational context needs to incorporate the operational and strategic management view (Slack, Chambers, and Johnston, 2007) if the knowledge management models are reflecting the economic and behavioral pragmatic reality in profit-based and non-profit based organizations. The cognitive sociology model of information seeking is a subset of the knowledge management models.

Within the information science view the concept of work task is seen to contain at least one “information seeking task as subtasks and that each information seeking task contains one or more information search tasks” (Byström and Hansen, 2005, p. 1058). All information source types may be part of the information search task. The authors stress a perspective of both work context and situation of which the task is one component.

Cognitive sociology for information seeking can be incorporated as one aspect of a broader framework in cognitive task analysis (Crandall, Klein, and Hoffman, 2006, p. 245-257). This approach focuses on individuals and team's work task strategies (goals) in real world contexts to understand the reasoning and decision-making.

The definition of a cognitive task analysis according to the authors are “activities of perceiving and attending that underlie performance of tasks, the cognitive skills and strategies needed to respond adeptly to complex situations, and the purposes, goals, and motivations for cognitive work”. The tasks are “outcomes people are trying to achieve”. The analysis is “procedures for systematic, scientific examination to support description and understanding”. The analysis can also be used in systems development to identify key cognitive drivers in many application types (Crandall, Klein, and Hoffman, p. 3-4, 2006).

The cognitive task analysis approach is lacking a thorough organizational embeddedness. This aspect is only covered by more loosely coupled general factors as ‘situational’ and ‘work place practice and design’. Cognitive sociology is intended to solve this deficiency.

The applications of the systematic framework in cognitive task analysis within an organizational understanding are diverse and can be mission critical for the organizations in which the work task is being solved. For example, the areas covered can be:

Information system development: A comprehensive understanding of the actors’ decision-making and strategies to optimize the utilization of the tools and the content of the information systems. The purposes are to facilitate both subject matter experts (extracting tacit knowledge) and novices. The usability approach is a subfield of cognitive task analysis applying the cognitive engineering theories (Rasmussen, Pejtersen, and Goodstein, 1994).

Training: Particularly on-the-job training can improve instructional practice by having the trainee taking an active role in the process “even directing the process by probing the subject matter expert”. The cognitive task analysis can help “subject matter experts articulate the subtle aspects of their expertise in on-the-job settings and having the trainees learn to ask better questions” (Crandall, Klein, and Hoffman, 2006, p. 253).

Organizational design: Team-based cognitive task analysis can improve understanding of how organizations assign tasks to improve coordination.

Market research: Cognitive task analysis focus on what consumers’ know, how they think, and their developed strategies for buying and using products. The analysis provides the reasoning for purchasing a particular product, brand, and its features. Furthermore, the product developers and the sales employees may use the corporation’s products or services in other ways than anticipated (Crandall, Klein, and Hoffman, 2006, p. 228). For example, in information seeking we can measure and analyze the problem recognition, formulation,

and problem resolution by search tactics, navigation, and search results when a consumer needs to purchase a new cell phone on the market. This work task may encompass previous own experience, virtual inspection of product offerings from online inventories, physical inspection, personal recommendations, public advertisements, and independent consumer guides.

2.7 Usefulness

The criteria of relevance or usefulness have showed a very diverse interpretation in the theoretical and empirical based research. The selection of relevance as the overall and core concept of evaluation measure in IR has reached consensus although intensively discussed, throughout the field of information science, see i.e. Su, 1993; Mizzaro, 1997; Saracevic, 2007a, b). The qualitative derived analysis of relevance criteria is carried out in four recent major researches: Schamber, 1991; Park, 1993; Barry, 1994; White and Wang, 1997.

The criteria of usefulness applied by information seekers in the present study during the search sessions and in the selection of references in their final work product are based on the utterances of the participants in their own natural language. In the process of probing the reasons for selection or rejecting the information sources, the basic check list of usefulness criteria is suggested. The selected criteria are chosen on the background of earlier research and an emphasis on classification principles consisting of disjunctive classes and exclusivity. The complexity and dynamic character of the relevance assessment process means that the core criteria may be interpreted as an idealized and simplified classification of relevance criteria. The relation of the core relevance criteria in the present research with the relevance criteria in the research of Schamber, Park, Barry, and White and Wang are described and illustrated below.

The criteria by Schamber are generally divided into information, source, and presentation. Some of the relevance criteria are especially applied for multimedia causing difficulties when comparing with other relevance research. The present research criteria for subject are similar to her 'specificity'. The present study's criteria for treatment/orientation are similar to her 'accuracy', 'reliability', 'verifiability', and 'clarity'. The present research criteria for currency are similar to her.

The criteria by Park are generally divided into internal experience context, external search context, and problem content context. The present study's criteria for subject are similar to her 'domain', 'definitions', 'background', and 'off the target'. The present study's criteria for treatment/orientation are similar to her 'methodology', 'analogy' and 'framework'. The present research's criteria for currency are similar to her 'new information' and 'old (repetitive) information'. The present research's criteria for authority are similar to her 'institutional affiliation' and 'journal main focus, status, and method'.

The criteria by Barry are generally divided into 'information content of document', 'user's previous experience and background', 'user's beliefs and preference', 'other information and sources within the information environment', 'sources of documents', and 'user's situation'. The present research criteria for subject are similar to her. The present research's criteria for treatment/orientation is similar to her 'depth/scope', 'objective' and 'subjective' 'accuracy/validity', 'tangibility', 'effectiveness', and 'clarity'. The present research's criteria for currency are similar to her. The present research's criteria for authority are similar to her 'external verification', 'source quality', and 'source reputation/visibility'. The present research's communication is similar to her 'ability to understand'.

White and Wang's criteria originate from two studies about relevance assessment during database searching and citation behavior.

The present research's criteria for subject are similar to theirs. The present research's criteria for treatment/orientation are similar to their 'orientation', 'depth', and 'audience'. The present research's criteria for currency are similar to their 'recency' for the user's subject and 'novelty' if the document is seen or known. The present research's criteria for authority are similar to their 'authority', 'prolific author', 'publicity', 'reputation', and 'standard reference'. The present research's communication is similar to their 'cognitive requisite'.

For some of the relevance criteria in the present research there are no direct connection to relevance criteria in the previous studies. The reason for this is, as stated above, the emphasis on classification principles of exhaustive and disjunctive classes. Furthermore, the purpose is a logic of dichotomies in the grouping of relevance criteria for subject, treatment/orientation, currency, and communication. The methodology is not applied in the previous studies in coding of the respondents' utterances which results in incoherent and overlapping relevance criteria. The lack of a prioritized set of most important criteria due to a 'naturalistic' or 'grounded' research methodology increase the problems of comparison and generalization, especially in the studies of Schamber, Park, and Barry.

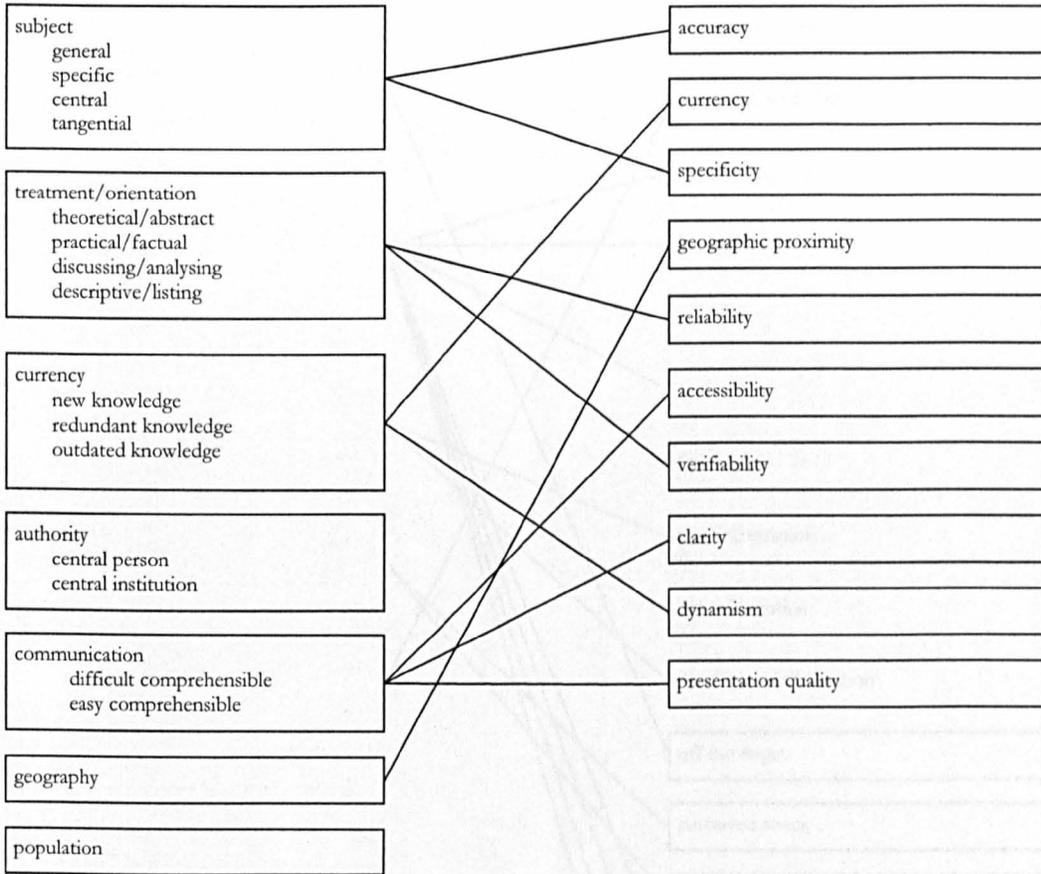
The groups of relevance criteria dealing with subject and treatment/orientation may result in rejecting or accepting information sources depending on the information seeking context, the work task, user background and the information sources itself.

The group of relevance criteria labeled currency may be interpreted as the actor's understanding of what is new, redundant, or outdated knowledge. The term 'redundant' encompasses either information sources seen before or information sources which might be judged redundant, although not evaluated in its full content because of close similarity with other information sources within a search session. The search tactic may result in rejection of information sources because the cost of evaluating the whole set of information sources is estimated to be above the threshold of the estimated benefit by evaluating the entire set of information sources. The not evaluated set of information sources might therefore be coded 'redundant'.

Below is illustrated the alignment of the key empirical relevance research displayed for each previous research finding with the core relevance criteria applied in the present research (figure 4).

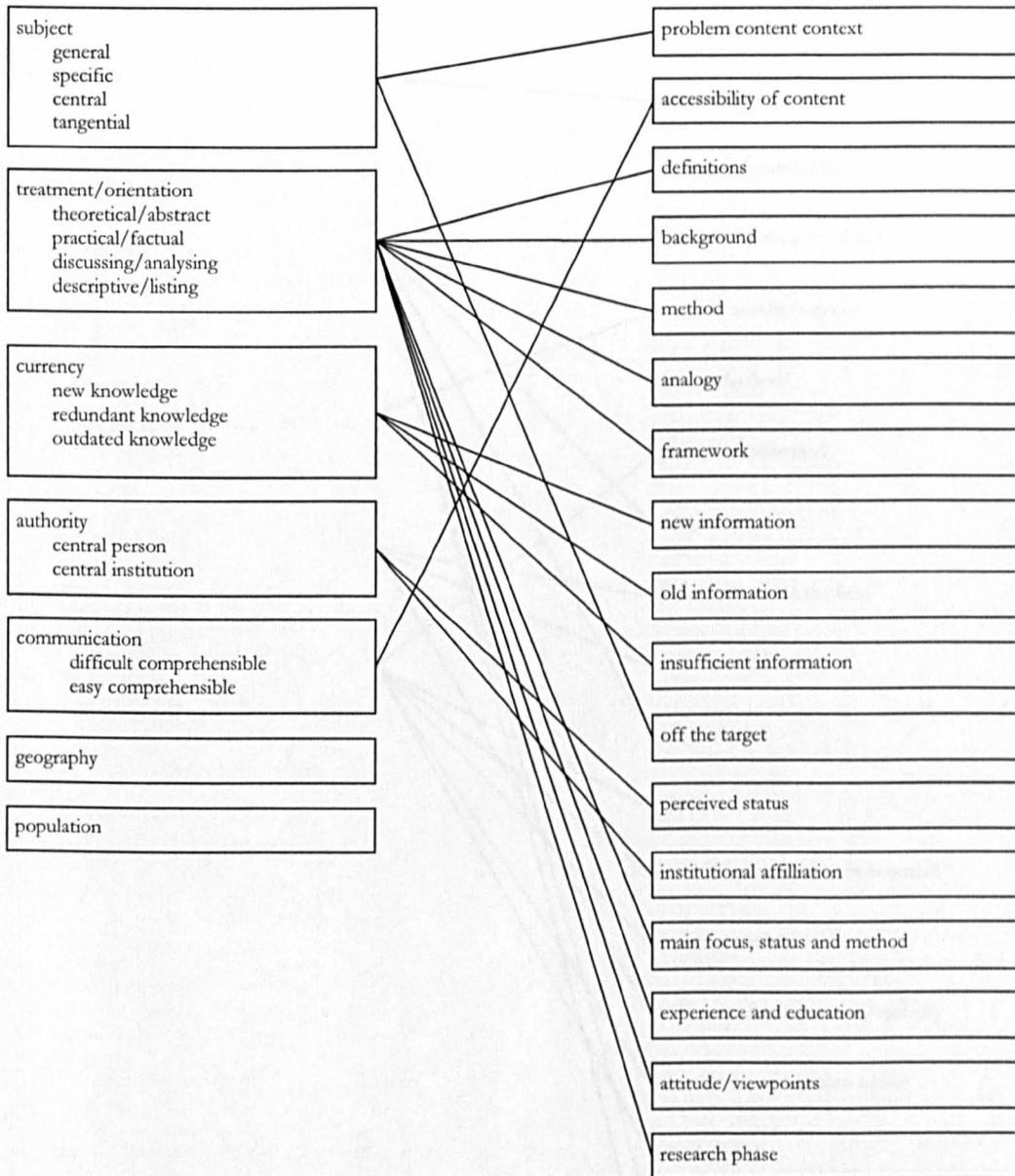
Core relevance criteria

Schamber



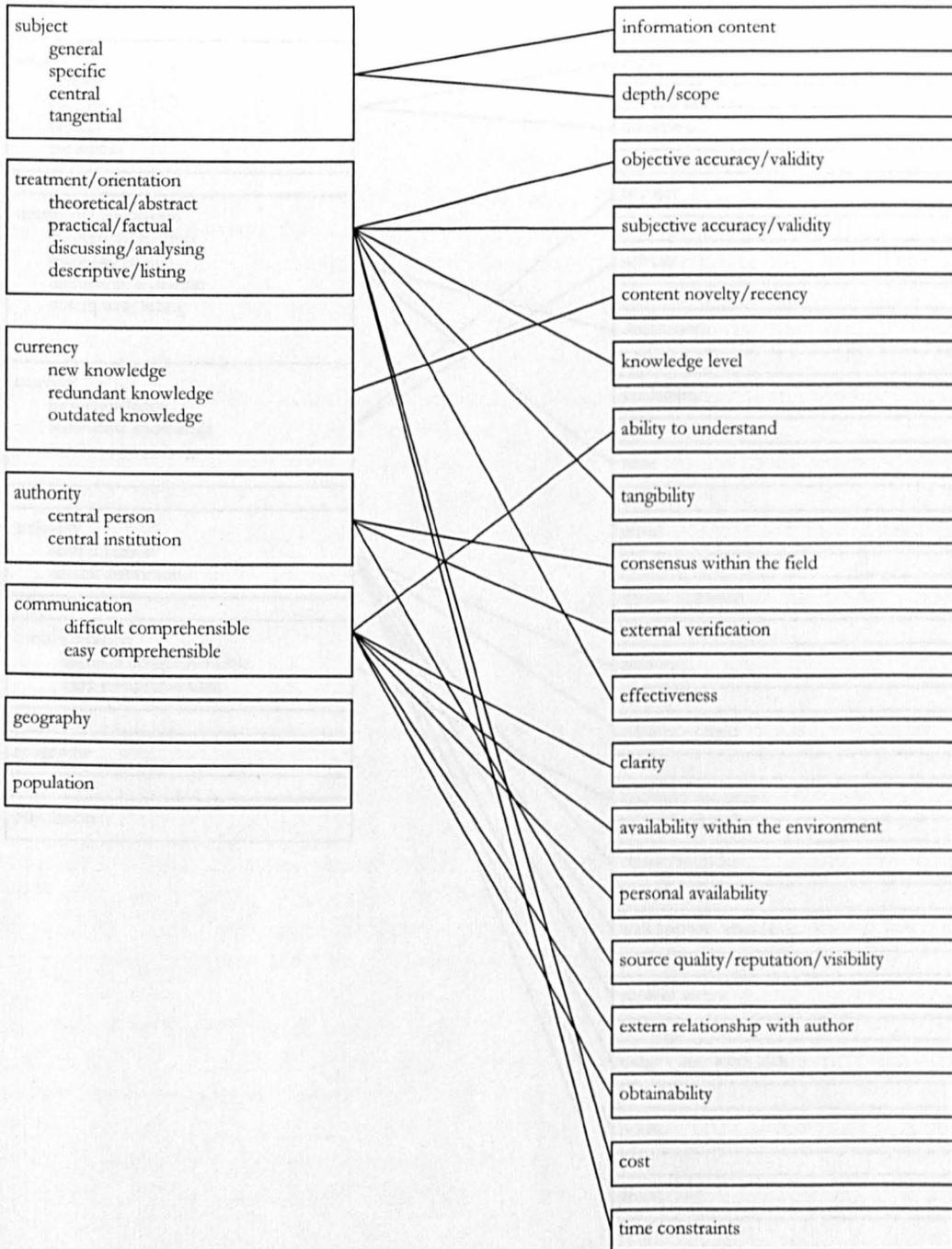
Core relevance criteria

Park



Core relevance criteria

Barry



Core relevance criteria

White and Wang

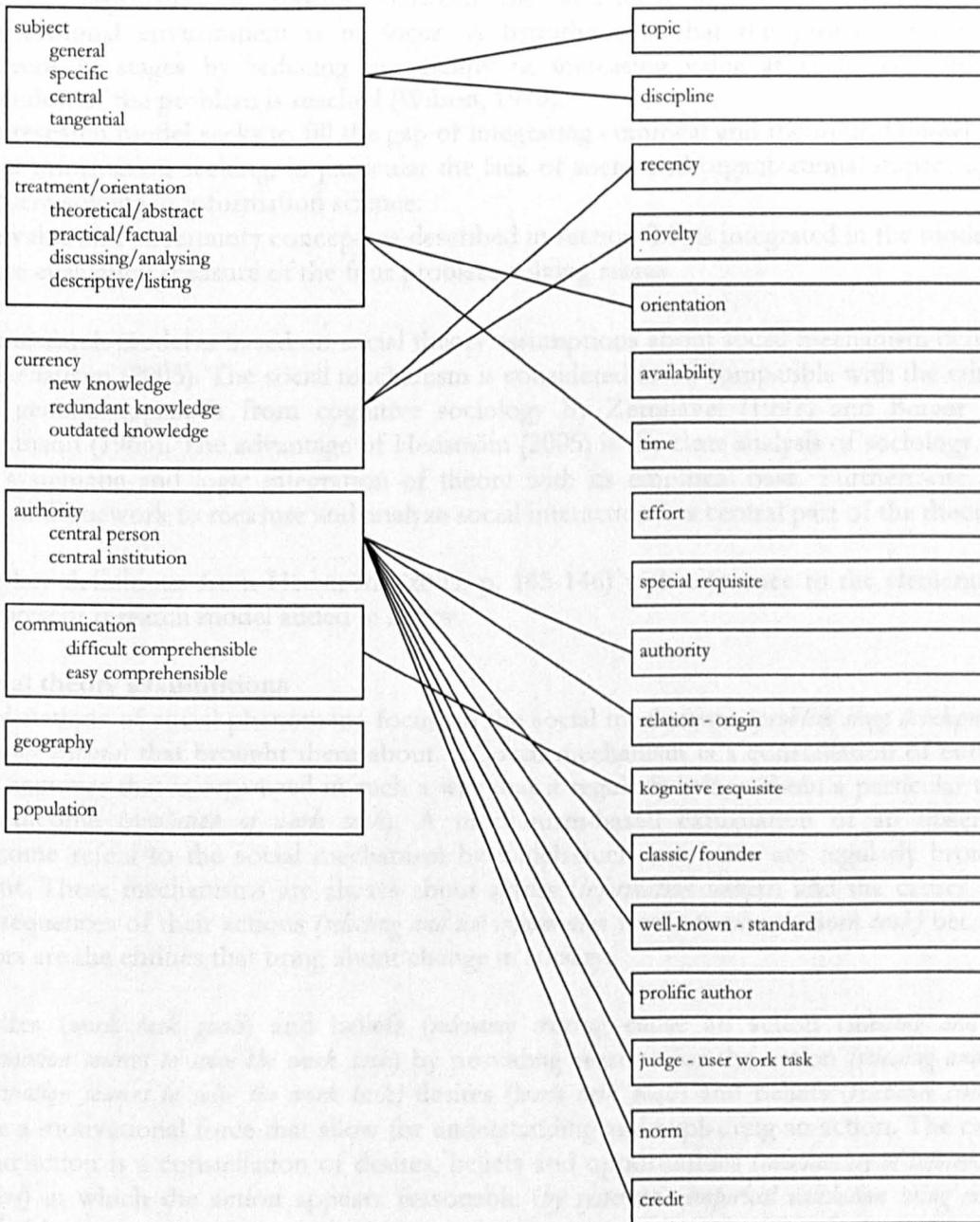


Figure 4: Core relevance criteria's relation to previous relevance research

3. Research model

The research model investigates the social mechanism relating to the beliefs about how information sources contribute to the actor's work task (information sources and relevance criteria). Especially the relation between the individual actor and the social and organizational environment is in focus. A hypothesis is that the problem resolution proceeds in stages by reducing uncertainty or increasing value at each stage until a resolution of the problem is reached (Wilson, 1999).

The research model seeks to fill the gap of integrating empirical and theoretical knowledge about information seeking, in particular the lack of social and organizational impact upon problem solving in information science.

The value and uncertainty concept, as described in section 2.5, is integrated in the model as a core evaluation measure of the four problem-solving stages.

The research model is based on social theory assumptions about social mechanism defined by Hedström (2005). The social mechanism is considered to be compatible with the critical and generic approach from cognitive sociology by Zerubavel (1997) and Berger and Luckmann (1966). The advantage of Hedström (2005) is the clear analysis of sociology and the systematic and logic integration of theory with its empirical base. Furthermore, the formal framework to measure and analyze social interaction is a central part of the theory.

The key definitions from Hedström (2005, p. 145-146) with reference to the elements of the present research model added in italics:

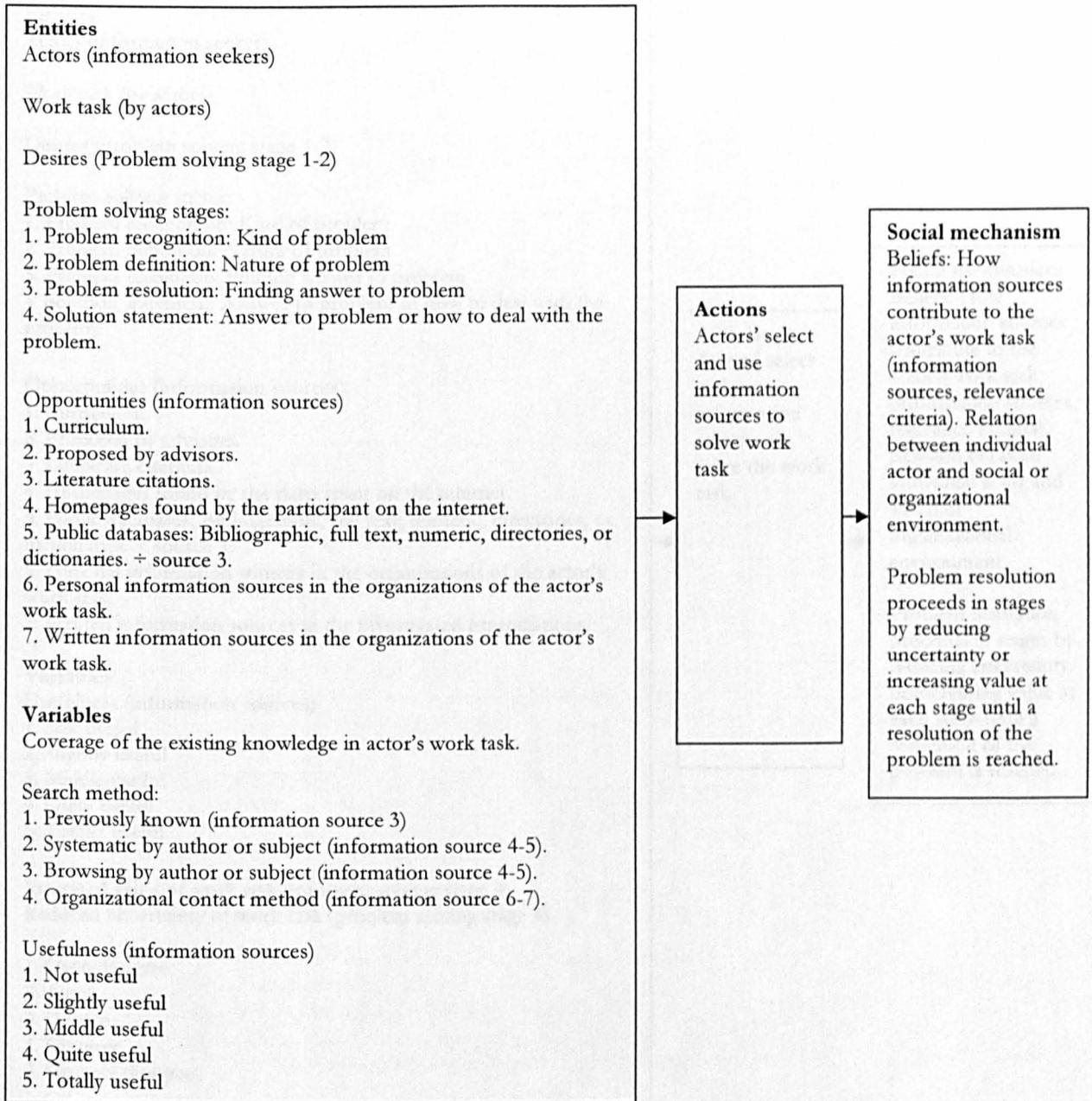
Social theory assumptions

Explanations of social phenomena focus on the social mechanism (*problem stage development, relevance criteria*) that brought them about. A social mechanism is a constellation of entities and activities that is organized in such a way that it regularly brings about a particular type of outcome (*resolution of work task*). A mechanism-based explanation of an observed outcome refers to the social mechanism by which such outcomes are regularly brought about. These mechanisms are always about actors (*information seekers*) and the causes and consequences of their actions (*selecting and use information sources to solve the work task*) because actors are the entities that bring about change in society.

Desires (*work task goals*) and beliefs (*relevance criteria*) cause an action (*selecting and use information sources to solve the work task*) by providing reasons for the action (*selecting and use information sources to solve the work task*) desires (*work task goals*) and beliefs (*relevance criteria*) have a motivational force that allow for understanding and explaining an action. The cause of an action is a constellation of desires, beliefs and opportunities (*availability of information sources*) in which the action appears reasonable (*by systematic empirical validation using mixed methodology*).

The research model is below for the qualitative and quantitative part (figure 5).

Qualitative part (theory explorative, case-based, micro-level)



Quantitative part (theory validation, generic, micro-macro link, survey)

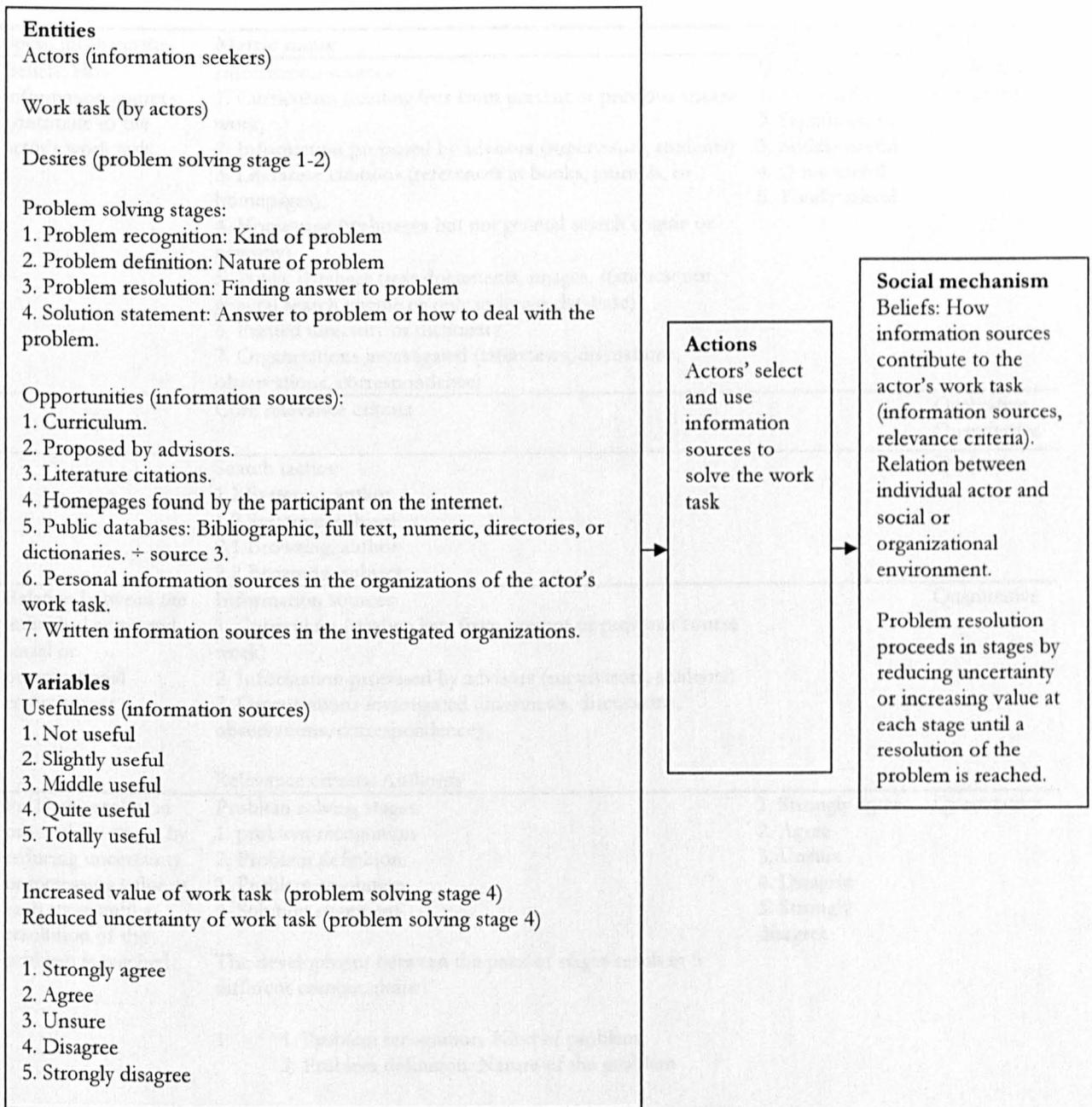


Figure 5: Research model

The implementation of the research model's metrics for the qualitative and quantitative part is displayed below (table 6).

Social mechanisms	Metric name	Scale	Part
Beliefs: How information sources contribute to the actor's work task	Information sources:	Usefulness:	Qualitative
	<ol style="list-style-type: none"> 1. Curriculum (reading lists from present or previous course work) 2. Information proposed by advisors (supervisors, students) 3. Literature citations (references in books, journals, or homepages) 4. Homepage (webpages but not general search engine or gateway) 5. Public database (text documents, images, statistics: not general search engine or only in-house database) 6. Printed directory or dictionary 7. Organizations investigated (interviews, discussions, observations, correspondence) 	<ol style="list-style-type: none"> 1. Not useful 2. Slightly useful 3. Middle useful 4. Quite useful 5. Totally useful 	Quantitative
	Core relevance criteria		Qualitative Quantitative
	Search tactics:		Qualitative
	<ol style="list-style-type: none"> 1.1 Systemic, author 1.2 Systemic, subject 2.1 Browsing, author 2.2 Browsing, subject 		
Relation between the individual actor and social or organizational environment	Information sources:		Quantitative
	<ol style="list-style-type: none"> 1. Curriculum (reading lists from present or previous course work) 2. Information proposed by advisors (supervisors, students) 7. Organizations investigated (interviews, discussions, observations, correspondence) 		
	Relevance criteria: Authority		
Problem resolution proceeds in stages by reducing uncertainty or increasing value at each stage until a resolution of the problem is reached	Problem solving stages:	<ol style="list-style-type: none"> 1. Strongly agree 2. Agree 3. Unsure 4. Disagree 5. Strongly disagree 	Quantitative
	<ol style="list-style-type: none"> 1. problem recognition 2. Problem definition 3. Problem resolution 4. Solution statement 		
	The development between the pairs of stages result in 5 different combinations:		
	<ol style="list-style-type: none"> 1. <ol style="list-style-type: none"> 1. Problem recognition: Kind of problem 2. Problem definition: Nature of the problem 		
	<p>Occurred:</p> <ol style="list-style-type: none"> 1. Separately? 2. Sequentially? 3. Overlapping? 4. Iteratively? 		
	<ol style="list-style-type: none"> 2. <ol style="list-style-type: none"> 2. Problem definition: Nature of the problem 3. Problem resolution: Finding an answer to the problem 		
	<p>Occurred:</p> <ol style="list-style-type: none"> 1. Separately? 2. Sequentially? 3. Overlapping? 		

-
3. 4. Iteratively?
 3. 3. Problem resolution: Finding an answer to the problem
 4. Solution statement: An answer to the problem or how to deal with it.

Occurred:

1. Separately?
2. Sequentially?
3. Overlapping?
4. Iteratively?

4. 1. Problem recognition: Kind of problem
4. Solution statement: An answer to the problem or how to deal with it.

Occurred:

1. Separately?
2. Sequentially?
3. Overlapping?
4. Iteratively?

5. 2. Problem definition: Nature of the problem
4. Solution statement: An answer to the problem or how to deal with it.

Occurred:

1. Separately?
2. Sequentially?
3. Overlapping?
4. Iteratively?

Hypotheses:

1. High distance in problem solving stage pairs (difference ≥ 2) results on average in a high probability of problem solving stage pairs occurring 'separately' (high mean).

2. High means of all problem solving stage pairs that occurred 'sequentially' result on average in a constantly progressing resolution of the work task without significant barriers, "anomalous state of knowledge" (Belkin, Oddy; and Brooks, 1982) or redefinition of the basic work task problem.

3. The dynamic development to reduce uncertainty or increase value through the 4 stages until the problem is solved: If uncertainty fails to be resolved at any one stage, it may result in a feedback loop to a previous stage for further resolution. The problem-solving process is seen as an iterative development. If the stage development is highly dynamic we expect high average values of 'overlapping' and 'iterative' problem solving stage types.

uncertainty stage =1 \rightarrow uncertainty level = \bar{x}

uncertainty stage =2 \rightarrow uncertainty level = \bar{x} - factor p

uncertainty stage =3 \rightarrow uncertainty level = \bar{x} - factor p x 2

uncertainty stage =4 \rightarrow uncertainty level = \bar{x} - factor p x 3

Problem solving stage 4: Solution statement: An answer to 1. Strongly agree

	the problem or how to deal with it (participant's perception):	2. Agree	
	1. Increased the value of the work task	3. Unsure	
	2. Reduced uncertainty of the work task (finished with a clear understanding of the dissertation problem)	4. Disagree	
		5. Strongly disagree	
Triangulation of method	External validation of final product of the participant's work task evaluated by the participant's dissertation supervisor subject to approval from the participating student.	Quantitative: 1-5 Qualitative: brief judgment	Qualitative Quantitative
	Examiner's role: Provide validation of existing literature on the subject of the dissertation.		
	1. Quantitative judgment: Does the citations cover the existing literature or knowledge in a satisfactory way.		
	2. Qualitative judgment of the citation's relevance for the master's dissertation.		

Table 6: Research model implementation

4. Methodology

In the following sections the research design, research method, data collection, and sample are described.

Research design

A mixed methodology approach was applied with a qualitative case-based study with developing working hypothesis and followed by a quantitative survey-based study with online questionnaire using similar research questions.

The impact of knowledge communities, which include the norms of problem definition and resolution, is reflected in the social and organizational environment where the information seeking takes place. The entities (work task, problem stages, information seekers, and information sources) and variables (usefulness and relevance criteria) are integrated elements which interact in a dynamic manner across time. The research design's qualitative part measures the impact of the social and organizational environment using utterances from the information seeker solving the work task and applies methodological triangulation by requesting the information seeker's examiner (of master dissertation) in his role as cognitive authority (control).

The research design is restricted to social science and applied sciences knowledge communities and may be interpreted according to this selection. The aim is to catch a broad range of information sources, search methods, and potential work tasks.

The field of information seeking is by nature dynamic. Every component in the research may be subject to change. The information seeker's problem, the knowledge community which the information seeker is a part of or/and aspires to, and the information objects which the information seeker are looking for. The information objects may be physical objects, texts, voices, or images which are in various degrees of stable conditions. Information objects as texts may be understood by accumulated knowledge representing 'facts' of the objective world or 'social construction' negotiated by members of social practice. "Social and natural facts are fairly stable constructs, but *as* constructions, they exist only as long as no one gives voice to powerful and persistent disagreement. No

established fact is immune against deconstruction” (Fuchs, 1992, p. 45-46). The interpretation of what is determined as stable or dynamic is crucial in choosing variables and entities to measure in researching information seeking.

The consequences of determining early in the research process a rigid and fixed research design with narrow possibility to adopt the dynamic reality may bias and narrow the research outcome. The possible bias and narrowness of the interpretation of results are minimized by selecting a longitudinal qualitative and quantitative research design which are flexible and time dynamic in definition of work tasks, search tactics, navigation, the usefulness of information sources, uncertainty phases, and outcome of work tasks.

The choice of data analysis method is multi-faceted; it is aimed at discovering the diversity of the information seeking *in* a context. The research is in a reality setting and is supposed to mirror life in its complexity, uncertainty, and dynamism. The implications of the complementary research methods are shown in a simplified form (table 7).

The combination of qualitative and quantitative methodologies called mixed model studies by Tashakkori and Teddlie (1998) is defined by the authors as “pragmatist paradigm that combines the qualitative and quantitative approaches within different phases of the research process”. There may be single applications within different phases of the study, such as a quantitative (experimental) design, followed by qualitative data collection, followed by quantitative analysis after the data are converted. In the present research, the qualitative data is converted into numbers using the ‘quantitizing’ technique described by Miles and Huberman (1994). There could also be multiple applications within phases of the study, such as the following:

- A research design that calls for a field experiment and extensive ethnographic interviewing to occur simultaneously and in an integrated manner.
- Data collection that includes closed-ended items with numerical responses as well as open-ended items on the same survey.
- Data analysis that includes factor analysis of Likert scaled items from one portion of the survey, plus use of the constant comparative method (Glaser and Strauss, 1967; Lincoln and Guba, 1985) to analyze narrative responses to open-ended questions theoretically linked to the Likert scales (p. 19).

Quantitative and qualitative methods are compatible. There is a lack of clear separation about what pragmatism is philosophically (Rorty, 2000) and in the practical dimension. We end in totally relativism and lacking coherent data analysis (Denzin and Lincoln, 2008) if the researcher may chose which theory he ‘likes’ for a research problem. The theories must be subject to scrutinized falsification procedures and there must warrant belief to chose one theoretical model instead of another one (Goldman, 1999).

The research process on any given question at any point in time follows within a cycle of inference processes, the research cycle, or scientific methodology. The cycle may be from grounded results (facts or observations) through inductive logic to general inferences (abstract generalizations or theory). Then from these general inferences or theory through deductive logic to tentative hypotheses or predictions of particular events/outcome. Research travels through this cycle at least once before it ends. The research may start at any point in the cycle. At some point during the research process both types of inferences and methods will be used simultaneously. When this occurs it is the “mixed model studies

with multiple applications within phase of study”, i.e. a mixing of both qualitative and quantitative approaches in at least one stage of the study during data collection and analysis (Tashakkori and Teddlie, 1998, p. 24-25). In the present research the type of methodology is explorative, i.e. search basically by inductive logic, but the research also search deductively by testing for the uncertainty’s hypothesis and social mechanisms as part of the research model. The present research does not attempt to predict behavior in a universal cause-effect law-like model, instead the research model emphasized the contextual factors, especially the social impact on the work task resolution.

Social science method	Qualitative	Quantitative
Context (situational and institutional factors)	Diversity, dynamism subjective interpretations Sample units selected purposely and selective due to the working hypothesis.	Simplified, controllable Sample units must be drawn independently of each other and randomly selected.
Truth	Depends on traditions, society, and situations of the investigated population.	Generalizations, representable Predictable (under prescribed conditions)
Verification and control of variables	Depends on the context. Verification is difficult because the research cannot be repeated under exactly the same conditions (as if it was a laboratory experiment)	Effective statistical tools if the variables can be operationable and countable.
Inferences	Understanding in context Why did A led to B? Why did X factor influence A, B, C...n group/individual?	Explaining correlation or variation between the variables within a restricted context or without a context (skipped in research design).

Table 7: Research methods implication

Data collection and analysis

Qualitative part

The qualitative data analysis methods are supported by the network technique of Miles and Huberman (1994). The displayed structure is tables which are published in a summarized version for each case and an aggregated version for all cases. Simple frequencies and averages were calculated by SPSS (Statistical Package for the Social Sciences). Submissions was online on a University of Sheffield hosted web server according to the think aloud procedures described below.

Registration and analysis of homepages and public database usage included tactics and navigation.

The *choice* is defined as the reasons why the information seeker selects any particular information source. The reasons were compared with the information seeker’s own description of previous knowledge and experience with the source in question.

The *search method* included the tactics and navigation applied to the selected information sources. *Tactic* is defined as in section 2.4. The *navigation* covers the actions performed to carry out the search, for example to scan the subject index of a database or to click a hyperlink in a web document.

Homepages

A homepage may be searched directly by means of the URL, and thus requires previous knowledge. Otherwise, meta search engines, domain search engines, or subject gateway² may be used. The search tools may be a combination of search engines, which perform the searches automatically, and subject gateways which entail human indexing.

For each homepage visited, the participant was requested to mention the tactics used and the navigation applied to reach the URL. If the address of a particular homepage was already known to the participant, he was asked to state the origin of this knowledge.

A meta search engine is basically an automatic retrieval engine which generates a temporary index of homepages which are publicly available to be caught (world wide web documents in HTML, XML, JPEG, GIF, and additional document file formats depending on the capabilities of the search engine and storage facilities). Since the meta search engines are primarily an *index of homepage* content and identification (URL), these search engines cannot be considered an information source per se. The 'catch' function of homepages is only a storage function on which the index is generated after the web crawler has retrieved its result at a given time. Each time the web crawler has performed its result, the previous 'catch' becomes obsolete unless stored for experiential or administrative statistical purposes. The ranking mechanism of the search engines is a central attribute generated from the search engine's algorithm. The ranking display and function is not considered in the present research when evaluating the 'found how' aspect of the participant's information sources in the qualitative part.

We are not considering in the present research a meta search engine's auxiliary functions, for example communication (E-mail, instant messaging, voice, document collaboration, calendar, and multimedia), mapping, automatic generated directories, mass media news, advertising, and office editing tools.

When classifying in the present research the source type of origin we must take into account in that order (1) the intellectual copyright holder or creator, (2) terms of copyright including distribution and licensing, (3) the publishing body, (4) information source format, and (5) dissemination methods. If we apply the classification method outlined, we are able to distinguish between for example an automatic news aggregator index³ who licenses news feeds, streaming, or 'caught' homepages from source of origin news corporations who have the intellectual copyright to the news stories. The news stories may be of text, image, or multimedia format. Unfortunately, it is not always transparent for the information seeker in the dynamic information space *who* has the *intellectual copyright* or is the *creator*, hence the source of origin. In the present research the participants were systematically queried by the researcher in the qualitative part to clarify the source of origin and any intermediary steps applied to search each information source cited in the participant's work task.

² The term subject gateway in the present research was used as the preferred term for gateway or portal. Please see a description from enterprise software application integrators of the corporate portal features integrating diverse information sources, applications, database types, collaboration tools, and access levels (SAP, 2008; IBM, 2008).

³ For example, provided free-based from Google.com and fee-based professional services from LexisNexis.com and Thomson.com

Public databases

The participant explained the tactics used and the navigation performed in his search. The data collection was based on a thinking aloud method. The tactics include the type of search. The search type may be verification of a particular document by an author/title or a subject search. A subject search may also be a search for an author representing a subject in which the participant is interested. The prevailing mode of navigation was examined as to whether browsing or systematic searching was preferred. Browsing is defined as an unstructured way of searching similar to the berry picking method proposed by Bates (1989). Systematic searching is defined as a conscious tactic, which follows a repeated pattern, procedure, or rule. Looking something up in a subject index is an example of systematic searching.

The information sources investigated by the participant were described at three levels: Which personal resources were used, how they were contacted, and how the information was collected.

The *use* of the information sources by the participants was prioritized among the various types of sources. Which sources of information became important for the final product constituting the dissertation for the master's degree? The participant was asked to tell about the references he found most relevant or useful. These references are defined as information sources, which were necessary for the creation of a satisfactory final product. Why and in what way did the information sources in question contribute to the student's final product?

The list of references stated by the participant in the final product was validated against existing literature on the subject of the dissertation. Did the citations cover the existing literature or knowledge in a satisfactory way? A satisfactory final product was evaluated by the organization within information seeking is taking place, i.e. the examiner of the participant's final product (qualitative part). The 'satisfaction' measure was the examiner's own interpretation; it was measured on a 5-point scale and supplemented by the examiner's brief comments. The validation was performed by the examiner after informed consent from the participants who wrote the dissertation. The students and the examiners were introduced to the validation procedure.

The data collection was registered in detailed case reports of information seeking. The elements in the case reports are shown in the appendices. The data collection during the participants' information seeking of homepages on the internet and publicly available databases was captured after the participants carried out their searching. The capture was via an online form at the University of Sheffield's web server. The structure of the participant-investigator dialog followed the research model's description. The role of the researcher was to develop and maintain an open and constructive dialog. The participant was encouraged to elaborate as explicitly as possible without constraint each information source visited. The core relevance criteria aided the probing of the participants during the evaluation of the usefulness of information sources. The participant was requested to mention the tactics used and the navigation applied to reach the URL ('how the participant reached the homepage'). If the address of a particular homepage was already known to the participant, he was asked to state the origin of this knowledge.

The structure and content of the data collection and analysis were described in the case reports (template in appendix). Since the qualitative part of the research was mainly exploratory, the development of the data collection and analysis was open to facilitate new or modified working hypotheses.

The case report both functioned as documentation for the research project and the external and internal examiners who validated the results and data collection methods.

An oral introduction for the participants (appendices) was given at the start of the interview. The only predetermined categorization applied during data collection was the usefulness scale. The four stages of the problem solving process were only used as guidance for the interview, not as fixed response options. The core relevance criteria were also only intended as a guide; the participants were encouraged to use their own words. The core relevance criteria helped to trigger the participant's memory and enabled the participant to understand the meaning of how the information source was used in the work task.

The motivation of the participants to participate was crucial. If capture of the participants' information seeking should be as thorough, systematic, consistent, and current as possible, the interview structure needed to be easy, simple, and quick to establish and execute. The interviews took place on campus at the university department where the participants were affiliated.

Quantitative part

The quantitative part was carried out on the online questionnaire hosted by a University of Sheffield's web server distributed to each participating department after departmental approvals. The questionnaire was with automatic validation of question response. The error rate of unfinished submitted questionnaires was therefore eliminated. The research problem was identical with the qualitative case-based part of the research but excluded the methodological triangulation implemented by the external evaluation of the examiner. Furthermore, the quantitative part did not include assessment of the participants' references in the work task.

The questions from the questionnaire (appendix) included a brief description of the work task (dissertation). A set of questions covered whether the four problem solving stages occurred separately, sequentially, overlapping, or iteratively. The participant was asked how uncertain he was at each stage of his work task. The most important information source types were ranked according to the participant's preferences. The participant was also asked to rank according to the importance of the core relevance criteria he selected to the information sources of the work task. Finally, the participant was instructed to agree or disagree on problem solving stage four about the 'solution statement: An answer to the problem or how to deal with it'. The judgment followed the research model's two aspects: He increased the value of his work task or reduced the uncertainty of the work task.

The response categories were according to a standard 5-point Likert scale on either nominal or ordinal level depending on the nature of the question. The questionnaire design minimized the 'do not know' response category to reduce the level of submissions with low data content. The basic concepts were defined and examples were given of information sources based on a pilot study among dissertation students from the University of Sheffield, Department of Information Studies.

The questionnaire submissions were analyzed using SPSS applying frequencies, averages, and bi-correlations (Kvanli, Pavur and Keeling, 2006) between the variables: Problem solving stages, information sources, relevance criteria, reduced uncertainty, and increased value.

$$r = \frac{\Sigma(x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma(x - \bar{x})^2} \sqrt{\Sigma(y - \bar{y})^2}}$$

The submissions were treated anonymously after data analysis. The participants could provide their name and E-mail address if they wished to participate in a pool for a draw of 10 x £ 10 vouchers to any product from www.amazon.co.uk. Furthermore, the participants could receive a response, if they wished, about how their submitted information was used in the research.

The data collection, analysis, and storage complied with the University of Sheffield's guidelines for research ethics published on the university's homepage. The participants in the online questionnaire survey were informed in the questionnaire itself about the compliance with the guidelines which took effect from 2005.

Sample

The samples consist of the qualitative and quantitative part. The qualitative part was graduate students of three different subjects at the University of Sheffield enrolled in Msc programs for 2001/02-2002/03 (table 8). The period was the last year of study within which they were scheduled to write their master's dissertation. The subject areas were primarily chosen because the researcher was most familiar with the social sciences. Business economics, business management, town and regional planning, and information management require theoretical as well as empirical information which is to be found within a wide range of sources. The number of potential participants was somewhat higher than the number expected to go through the entire research. The students could choose not to participate because it was disrupting or time consuming. The work task (dissertation) labeled 'case' constituted the entity of the sample. Thus, the number of work tasks to be investigated was dependent on the number of participants working on each case. All participants were working on an individual basis.

The quantitative part was graduate students of four different subjects enrolled in full-time Msc programs for 2003/04-2005/06 (table 8). One submission was declared invalid because all questions about problem solving stage development were answered with the same value '3' which resulted in a meaningless submission.

The period was the last year of study within which the participants were scheduled to write their master's dissertation. The subject areas were primarily chosen to obtain a diverse range of subjects reflecting different environments, methods, and information sources. Departments already participating in the case studies were excluded apart from the Department of Information Studies. The low response rate in the sub-samples is counter-balanced by repeated sampling in the sub-sample Information management which provided the largest response rate. There was no evidence which implied a strong bias in any particular direction of the submitted questionnaires measured by the results from the sample.

Part	Institution	Subject	Period	Contribute	Potential
Qualitative	University of Sheffield	Leisure management	2001/02-2002/03	3	20
Qualitative	University of Sheffield	Town and regional planning	2001/02-2002/03	2	17
Qualitative	University of Sheffield	Information management	2001/02-2002/03	9	84
Quantitative	University of Sheffield	Information management	2003/04-2005/06	32	114 (2003/04) 101 (2004/05) 97 (2005/06)
Quantitative	University of Sheffield	Medicine	2004/05	4	109

Quantitative	University of Sheffield	Automatic control and systems engineering	2003/04	1	96
Quantitative	IT University of Copenhagen	IT	2005/06	3	67

Table 8: Sample from the qualitative and quantitative part

5. Results and discussion

The results are based on the qualitative case-based part and the quantitative survey-based part which are described below.

5.1 Qualitative part

Below are listed all the cases in a summary format including work task description, and confirmation of the hypothesis of increased value or reduced uncertainty. Search tactics, information source type, relevance criteria, search services, and total number of references are listed. Finally, the summary contains the marking done by the examiner about the coverage of the existing knowledge of the work task (table 9).

Case 1

Participant record date	9/9/03
Work task description	Public library provision of large print fiction for the elderly
Increase value and reduce uncertainty	√ The librarian and the publishers consider the needs of the readers
Search tactic	Systemic - author: 0 Systemic - subject: 47 Browsing - author: 2 Browsing - subject: 5
Information source	Curriculum: 1 Advisor: 2 Literature citation: 9 Homepage: 1 Database: 53 Printed directory or dictionary: 1 Organization investigated: 0
Relevance criteria	Subject - general: 4 Subject - central: 2 Treatment/orientation: 18 Treatment/orientation - theoretical/abstract: 5 Treatment/orientation - practical/factual: 6 Treatment/orientation - discussing/analyzing: 37 Treatment/orientation - descriptive/listing: 4 Currency - redundant knowledge: 2 Geography: 1
Web search service type ¹	-
Human search assistance ²	-
References	67
Coverage of existing knowledge	4

Case 2

Participant record date	10/9/03
Work task description	Reference price (customer's expectations about price compared with the quality of service) for public swimming sessions at [x] swimming

	pool
Increase value and reduce uncertainty	√ Research showed that it worked – this message did enhance their reference price in their mind.
Search tactic	Systemic - author: 0 Systemic - subject: 13 Browsing - author: 0 Browsing - subject: 3
Information source	Curriculum: 3 Advisor: 13 Literature citation: 1 Homepage: 0 Database: 17 Printed directory or dictionary: 0 Organization investigated: 0
Relevance criteria	Subject: 14 Subject - general: 5 Subject - specific: 1 Subject - central: 4 Treatment/orientation: 3 Authority - central person: 7
Web search service type ¹	-
Human search assistance ²	-
References	34
Coverage of existing	3

Case 3

Participant record date	18/10/02
Work task description	Evaluation for sports project (football and basketball mainly) for disaffected young people (10-24 - focus 12-16) in [x] council
Increase value and reduce uncertainty	√ Project was not having much impact upon the participants – it was not directing them away from crime or anything like that which it was meant to do.
Search tactic	Systemic - author: 5 Systemic - subject: 7 Browsing - author: 0 Browsing - subject: 9
Information source	Curriculum: 5 Advisor: 20 Literature citation: 11 Homepage: 4 Database: 19 Printed directory or dictionary: 0 Organization investigated: 1
Relevance criteria	Subject: 34 Subject - general: 4 Subject - specific: 1 Subject - central: 2 Subject - tangential: 6 Treatment/orientation: 8 Treatment/orientation - discussing/analyzing: 5 Treatment/orientation - descriptive/listing: 2 Currency - new knowledge: 1 Currency - outdated knowledge: 2 Authority - central institution: 1 Geography: 2
Web search service type ¹	-
Human search assistance ²	-

References	60
Coverage of existing knowledge	5

Case 4

Participant record date	7/10/02
Work task description	Overseas visitors satisfaction of [x]International Festival
Increase value and reduce uncertainty	√ My findings and the findings in the literature - some of them are different but some steers the same pattern.
Search tactic	Systemic - author: 7 Systemic - subject: 19 Browsing - author: 2 Browsing - subject: 2
Information source	Curriculum: 0 Advisor: 0 Literature citation: 0 Homepage: 3 Database: 20 Printed directory or dictionary: 0 Organization investigated: 7
Relevance criteria	Subject: 17 Subject - specific: 3 Subject - central: 2 Treatment/orientation: 7 Treatment/orientation - discussing/analyzing: 1
Web search service type ¹	-
Human search assistance ²	-
References	30
Coverage of existing knowledge	4

Case 5

Participant record date	1/7/03
Work task description	English librarians' attitude to the Booker Prize (general conception). Generalization from 17-18 librarians in the [x] of England. Relevance of the price for public libraries - do the people (users) need a guide to recommend for a lot of people? Personal attitudes and library policies.
Increase value and reduce uncertainty	√ Differences in attitude to the Booker's role - other prizes are more relevant for libraries. I got a more positive attitude to the Booker Prize: Publicity - encourage people to read. Booker Prize's judge are good - appeals to a wider range of people - publicity and authority.
Search tactic	Systemic - author: 0 Systemic - subject: 11 Browsing - author: 0 Browsing - subject: 13
Information source	Curriculum: 39 Advisor: 4 Literature citation: 9 Homepage: 9 Database: 14 Printed directory or dictionary: 0 Organization investigated: 1
Relevance criteria	Subject: 17 Subject - general: 2 Subject - specific: 4 Subject - central: 1 Subject - tangential: 1 Treatment/orientation: 18

	Treatment/orientation - discussing/analyzing: 32 Geography: 3
Web search service type ¹	Search engine (1)
Human search assistance ²	-
References	76
Coverage of existing knowledge	5

Case 6

Participant record date	17/7/03
Work task description	Relationship marketing on the internet - looking at different ways in which companies use web tools. Company types: Brick and clicks (physical presence and online presence) and pure plays relationship. Look on various communication methods to build trust with customers and web design and usability - how it helps deploy relationship marketing.
Increase value and reduce uncertainty	√ Bricks and Clicks would be more likely to succeed. Web tools are better for Pure Plays if they have tools to personalize web sites - e.g. Amazon with suggestions of what you might like. User interface must be easy to use because they don't have the physical relationship to build on.
Search tactic	Systemic - author: 3 Systemic - subject: 27 Browsing - author: 0 Browsing - subject: 9
Information source	Curriculum: 3 Advisor: 2 Literature citation: 11 Homepage: 3 Database: 37 Printed directory or dictionary: 0 Organization investigated: 10
Relevance criteria	Subject: 28 Subject - general: 3 Subject - specific: 2 Subject - central: 1 Treatment/orientation: 8 Treatment/orientation - theoretical/abstract: 3 Treatment/orientation - practical/factual: 14 Treatment/orientation - discussing/analyzing: 4 Treatment/orientation - descriptive/listing: 2 Currency - new knowledge: 1 Authority - central person: 7 Communication - easy comprehensible: 2 Geography: 1
Web search service type ¹	Search engine (1), subject gateway (1)
Human search assistance ²	-
References	66
Coverage of existing knowledge	4

Case 7

Participant record date	4/9/03
Work task description	Evaluation of an image retrieval system's automatic annotation component
Increase value and reduce uncertainty	√ Narrow focus to error rate and subsequent influence on retrieval - formulate methodology which enabled to give quantitative data. Each caption: How well does it fit with the image (scale: 1-3). Basic statistics: How well have the annotations been made. Developed

	little program to do aid analysis of retrieval error.
Search tactic	Systemic - author: 0 Systemic - subject: 19 Browsing - author: 0 Browsing - subject: 1
Information source	Curriculum: 2 Advisor: 10 Literature citation: 3 Homepage: 0 Database: 20 Printed directory or dictionary: 0 Organization investigated: 0
Relevance criteria	Subject: 7 Subject - general: 12 Subject - specific: 1 Subject - central: 1 Treatment/orientation: 15 Treatment/orientation - discussing/analyzing: 4
Web search service type ¹	Search engine (1), subject gateway (1)
Human search assistance ²	-
References	35
Coverage of existing knowledge	4

Case 8

Participant record date	5/9/03
Work task description	The analysis of research concerning the information needs of people with multiple sclerosis
Increase value and reduce uncertainty	√ [Patients] do not want information about possible physical symptoms (denial). Reject information as a way to cope with a stressful situation at the time of diagnosis. People with more serious sclerosis find it more difficult to get information. Not confident to go out to find the information - physical constraints - ex. wheel chair users. Health professionals were at the time of diagnosis generally unhelpful - patronizing them - lack of advice/support of diagnosis.
Search tactic	Systemic - author: 0 Systemic - subject: 6 Browsing - author: 0 Browsing - subject: 2
Information source	Curriculum: 4 Advisor: 5 Literature citation: 26 Homepage: 8 Database: 6 Printed directory or dictionary: 1 Organization investigated: 0
Relevance criteria	Subject: 20 Subject - specific: 1 Subject - central: 1 Subject - tangential: 1 Treatment/orientation: 19 Treatment/orientation - practical/factual: 1 Treatment/orientation - discussing/analyzing: 2 Treatment/orientation - descriptive/listing: 5
Web search service type ¹	Search engine (1)
Human search assistance ²	-
References	50
Coverage of existing knowledge	5

Case 9

Participant record date	5/9/03
Work task description	Use of images in understanding of documents in cross-language information retrieval
Increase value and reduce uncertainty	√ Some use could be made but that images cannot communicate all that language can. It might be useful for concrete nouns but higher level concepts are hard to represent in images, as is structure in a document.
Search tactic	Systemic - author: 1 Systemic - subject: 6 Browsing - author: 0 Browsing - subject: 3
Information source	Curriculum: 8 Advisor: 4 Literature citation: 7 Homepage: 4 Database: 20 Printed directory or dictionary: 0 Organization investigated: 0
Relevance criteria	Subject: 28 Subject - tangential: 1 Treatment/orientation: 11 Treatment/orientation - practical/factual: 1 Treatment/orientation - discussing/analyzing: 3
Web search service type ¹	Search engine (1)
Human search assistance ²	-
References	43
Coverage of existing knowledge	5

Case 10

Participant record date	10/9/03
Work task description	An investigation of non-academic composition and how non-academic composers interact with electro-acoustic software and the studio environment around them.
Increase value and reduce uncertainty	√ Focus on professional composers at the beginning, but the composers at the [x] studio were mainly amateurs. Big need for music composition software companies to get together and introduce standard so that music composers are better able to interact. Different software packages have different problems.
Search tactic	Systemic - author: 1 Systemic - subject: 5 Browsing - author: 0 Browsing - subject: 16
Information source	Curriculum: 3 Advisor: 10 Literature citation: 9 Homepage: 2 Database: 23 Printed directory or dictionary: 0 Organization investigated: 1
Relevance criteria	Subject: 12 Subject - general: 1 Subject - central: 2 Treatment/orientation: 28 Treatment/orientation - theoretical/abstract: 4 Treatment/orientation - practical/factual: 6

	Treatment/orientation - descriptive/listing: 1
Web search service type ¹	Search engine (1), subject gateway (1)
Human search assistance ²	-
References	48
Coverage of existing knowledge	4

Case 11

Participant record date	8/9/03
Work task description	Information skills for the voluntary sector workforce: A multiple case analysis of umbrella organizations (organizations which exist to help other small group to operate - physical facilities, information service, and infrastructure) within [x] county 1. What skills are required for the effective management of information by voluntary sector workers within umbrella organizations? 2. Are these skills different to those required by employees within other sectors (public/private)?
Increase value and reduce uncertainty	√ Answered 1st question thoroughly and partly the 2nd question - problem different in public/private organization than in a voluntary environment - some combination of the skills listed are possible more valuable but needs further work.
Search tactic	Systemic - author: 0 Systemic - subject: 20 Browsing - author: 0 Browsing - subject: 9
Information source	Curriculum: 8 Advisor: 4 Literature citation: 6 Homepage: 1 Database: 29 Printed directory or dictionary: 0 Organization investigated: 1
Relevance criteria	Subject: 9 Subject - general: 3 Subject - specific: 9 Subject - central: 3 Subject - tangential: 5 Treatment/orientation: 15 Treatment/orientation - theoretical/abstract: 2 Treatment/orientation - practical/factual: 4 Treatment/orientation - discussing/analyzing: 3 Treatment/orientation - descriptive/listing: 2 Currency - redundant knowledge: 2 Currency - outdated knowledge: 1 Authority - central person: 3 Communication - difficult comprehensible: 2 Population - attributes: 1
Web search service type ¹	Search engine (1)
Human search assistance ²	-
References	50
Coverage of existing knowledge	5

Case 12

Participant record date	24/9/03
Work task description	Academic library resource fund allocation to subject areas: Practice, theory, and future possibilities.
Increase value and reduce uncertainty	√ There is no universal answer, allocation methods need to be developed to suit individual institutions

Search tactic	Systemic - author: 0 Systemic - subject: 24 Browsing - author: 0 Browsing - subject: 1
Information source	Curriculum: 1 Advisor: 0 Literature citation: 9 Homepage: 0 Database: 24 Printed directory or dictionary: 0 Organization investigated: 1
Relevance criteria	Subject - general: 1 Treatment/orientation: 2 Treatment/orientation - practical/factual: 29 Authority - central person: 4
Web search service type ¹	Search engine (1)
Human search assistance ²	-
References	35
Coverage of existing knowledge	4

Case 13

Participant record date	7/10/03
Work task description	Partnership work in a field of diverse interests: The experience of the [x] Transport Forum (partnership of local authorities)
Increase value and reduce uncertainty	√ Partnership made very heavy use of technical studies in order to create consensus between the partnerships which have also resulted in a number of assumptions within the partnership about transport that are never challenged and become unimpeachable 'knowledge'. The key assumption is that if the movement of traffic is restrained in one part of the park, then road construction must occur elsewhere in order to accommodate diverted traffic. The partnership fails through these assumptions to fully consider environmental factors. The partnership was subject to non-consensual practices.
Search tactic	Systemic - author: 1 Systemic - subject: 4 Browsing - author: 0 Browsing - subject: 2
Information source	Curriculum: 20 Advisor: 19 Literature citation: 17 Homepage: 0 Database: 6 Printed directory or dictionary: 0 Organization investigated: 39
Relevance criteria	Subject: 7 Subject - general: 16 Treatment/orientation: 21 Treatment/orientation - theoretical/abstract: 24 Treatment/orientation - practical/factual: 8 Treatment/orientation - discussing/analyzing: 43 Population - attributes: 1
Web search service type ¹	-
Human search assistance ²	-
References	101
Coverage of existing knowledge	5

Case 14

Participant record date	31/1/04
Work task description	Analyze the Economical (low price) and Comfortable Housing (ECH) in China with the urban economics and housing economics; reveal the price mechanism of ECH and explore why the policy designed affordable housing becomes unaffordable for the disadvantaged groups in the open market after housing policy reform.
Increase value and reduce uncertainty	√ Housing price is affordable for the disadvantaged groups according to the empirical policy data. Theoretically the housing price is not affordable. In practice, the housing is not affordable.
Search tactic	NA
Information source	Curriculum: 0 Advisor: 6 Literature citation: 7 Homepage: 1 Database: 0 Printed directory or dictionary: 0 Organization investigated: 15
Relevance criteria	Subject - general: 8 Subject - specific: 17 Subject - central: 2 Subject - tangential: 2 Treatment/orientation - theoretical/abstract: 1 Treatment/orientation - practical/factual: 2 Treatment/orientation - discussing/analyzing: 6 Treatment/orientation - descriptive/listing: 20 Currency - new knowledge: 24 Currency - outdated knowledge: 5 Authority - central person: 24 Authority - central institution: 6 Communication - difficult comprehensible: 1 Communication - easy comprehensible: 27
Web search service type ¹	NA
Human search assistance ²	NA
References	29
Coverage of existing knowledge	NA

Table 9: Case summaries

¹ Subject gateway and search engine

² Information specialist, student, or faculty

³ Scale: 1-5 (1: No satisfactory coverage; 5: Fully satisfactory coverage)

In the following section the results are displayed on an aggregated case level covering the variables search type, information sources, and relevance criteria. Finally, the external evaluation concerning the participant's coverage of the existing knowledge of the subject is displayed.

The ranking of the search tactic types clearly shows that the systematic subject searching and browsing are predominant while systematic or browsing author searching have an insignificant role (table 10). It must be stressed that the participant's search tactics are different from each other and only apply for the information sources homepage (4), database (5), and organizations investigated (7). The minimum number of cases is at a valid level for the systematic and browsing subject search tactics.

Rank	Search Tactic Type	Percent	n
3	Systemic – author	5,90	6
1	Systemic – subject	68,20	13
4	Browsing – author	1,30	2
2	Browsing - subject	24,59	13
	Σ	99,99	

Table 10: Ranking of search tactic type

n=13. \bar{x} . 1 case has no values

The most important information sources used which were judged quite or very useful (4-5) by the participants showed that about 1/3 of the sources were found by independent database searching (table 11). The influence from the knowledge community, which in the cognitive sociology model is categorized as the institutional factors, attributes for about 1/4 of the most important information sources. Those sources consist of the curriculum (12,6 %) and recommended by advisors (15 %). If the influence from the investigated organizations (13,8 %) is included in the institutional factors the overall share amounts for 1/3 of the most useful information sources. Literature citations had a firm and significant influence but were not predominant accounting for only 15,2 % of the most important information sources. Homepages had an unimportant role among the most important information sources for the work task with only 4,6 %. Printed directories and dictionaries were practically not included in the references by the participants.

Rank	Percent	Number	Type
5	12,56	52	Curriculum
3	14,98	62	Advisor
2	15,22	63	Literature citation
6	4,59	19	Homepage
1	38,65	160	Database
7	0,24	1	Printed directory or dictionary
4	13,77	57	Organization investigated
	100,01	414	Σ

Table 11: Most useful information sources

n=14. \bar{x} . Rating: 4-5.

The relevance criteria applied for the cited references are classified according to the core relevance criteria was measurable and understood by the participants (table 12). The extent varied among the participants if they were able to adopt the predefined relevance criteria with only a brief introduction to the system and definitions or the participants preferred their own relevance concepts which was then continuously elaborated and clarified in dialog with the researcher. The quantification of the criteria must be interpreted as only indicative and used as a guide to evaluate what main factors influence the judgment process of the citations included in the participants' final work. Previous research (Schamber, 1991; Park, 1993; Barry, 1994; White and Wang, 1997) confirmed the importance of topical relevance but also showed that the treatment or orientation of the information sources is significant. The influence of authoritative persons and institutions did not play an important role. The currency aspect was not a determining factor in the selection of the

cited references. The selection of domains in the sample of participants are intended to reflect subjects of high as well as lower levels of currency focus.

Relevance Criteria	N cases	Σ groups	Σ
1. Subject	11		193
2. Subject – general	11		59
3. Subject – specific	9		39
4. Subject – central	11		21
5. Subject – tangential	6	Σ_{1-5} 328	16
6. Treatment/orientation	13		173
7. Treatment/orientation - theoretical/abstract	6		39
8. Treatment/orientation - practical/factual	9		71
9. Treatment/orientation - discussing/analyzing	11		140
10. Treatment/orientation - descriptive/listing	7	Σ_{6-10} 459	36
11. Currency – new knowledge	3		26
12. Currency - redundant knowledge	2		4
13. Currency - outdated knowledge	3	Σ_{11-13} 38	8
14. Authority - central person	5		45
15. Authority - central institution	2	Σ_{14-15} 52	7
16. Communication - difficult comprehensible	2		3
17. Communication - easy comprehensible	2	Σ_{16-17} 32	29
18. Geography	4		7
19. Population	2		2

Table 12: Total usage of relevance criteria in the cited references

n=14. The participants could apply multiple relevance criteria to each cited reference. The participants were free to decide if they would use the predefined relevance criteria applied by the researcher.

5.1.1 Problem solving stage development

There was no evidence supporting a hypothesis about significant high levels of uncertainty at any of the four stages in the information seeking model. Furthermore, there was indication in all cases that the initial work task was solved. All participants had been able to reach a solution statement. Please refer to the case summary table of each case above in the row headed “increasing value and reducing uncertainty”. The texts are drawn for all cases from the participant’s own statement of stage 4 of the information seeking model: Solution statement: Answer to problem or how to deal with the problem.

There was no evidence of a clear progressing problem solving process with the information seeking following a particular linear or non-linear pattern. There are behavioral and cognitive limitations about verifying the statements of the participant’s problem solving process since we rely on his own interpretation of the process. The cognitive limitations encompass the selective and biased judgment and decision capabilities as outlined in section 2. Regarding the final product, we are able to verify if there is convergence between the participant solving the work task and the evaluator of the work task.

The problem resolution stage ‘finding an answer to the problem’ showed a diversity of methods and contexts. The extract from all cases are showed below:

ID 1: ‘Interviews and focus groups with librarians, publishers, and readers. Located participants via website of library authorities with list of contact persons. Called authorities to request addresses for relevant people. BT directory for locating publishers’

ID 2: 'Research on reference price (customer's expectations about price compared with the quality of service) for public swimming sessions at [x] Swimming Pool'

ID 3: 'I improved the whole methods [importance and performance analyzing measures like x, y, z to calculate which part of importance of satisfaction] in the literature I found'

ID 4: 'Work task did not change as such although I did have problems in that some of the participants did not want to be interviewed, and I was basing the research on that (...) Did not expect the children to be as bad as they actually were – a lot of them had a lot of problems – drug use, criminal background, and whatever'

ID 5: 'In depth survey: Interviews in order to get the opinions and reasons, not just a rather superficial questionnaire to a lot of librarians. Literature: Helps in asking questions - place subject in a wider context. Booker Prize: Example of literature fiction and role in a public library'

ID 6: 'Relationship marketing on the internet - looking at different ways which companies use web tools. Company types: Brick and Clicks (physical presence and online presence) and Pure Plays relationship. Look on various communication methods to build trust with customers and Web design and usability'

ID 7: 'Annotations from 500 images (system automatically generates annotations for the images)'

ID 8: 'Information at diagnosis, difficulties in finding information, and importance of information were investigated to see if they were significantly related to disease and demographic factors such as gender, age, or self-rated severity of symptoms of multiple sclerosis'

ID 9: 'Developed a questionnaire to test people's ability to understand the meaning of 25 sets of 8 images. A free format text field was presented. A second part showed the same 25 sets in a different order and provided multi-choice answers'

ID 10: 'Observed composers by sitting in recording room - making notes. If problem came up, then the composer would be interviewed later after the composition work. Submission of online questionnaire via 15 music forums (discussion boards). Received 35 replies. In addition, I looked on separate discussion boards who dealt with composition software problems'

ID 11: 'Case study research (5 organizations in [x], 1 national umbrella organization, 4 local organizations [a, b, c, d]. 1 interview per organization (contact person: management responsibility). Some have an information officer. Produced simple cognitive maps. Organizations told their organizational goals. Information needs derived from that - ex IT needs, editing needs, general writing skills'

ID 12: 'Literature review and field interviews'

ID 13: 'Policy plans and developments (all the local authorities), minutes of meetings of local authorities, public meetings and part of private meetings within partnership (10 years in general, one recent year in detail), senior planners, organizational spokesperson for the different partners in the partnership, archived interviews within and outside the partnership'

ID 14: 'Collect information about the ECH [Economic and Comfortable Housing] and compare ECH with housing economics and housing management theory'

The overview indicates that this stage of the problem solving stage is in general, apart from ID 4, fairly mechanical; the process appears to develop smoothly. When considering the variety and complexity of the methods, it is surprising that the process is linear and without information gap or an Anomalous State of Knowledge (ASK) according to the ASK

hypothesis (Belkin, Oddy, and Brooks, 1982). The researcher consistently asked the participants if there were any uncertainty or problems during their problem solving process.

We find the following dominating pattern for the cases if we review the information source types in relation to search tactic and relevance criteria for the most useful information sources (usefulness=4-5). Each case and a summary are listed below.

We find a pattern dominated by the relevance criteria: Subject and treatment/orientation searching by keyword and browsing for the information sources: public databases (9), advisors (5), curriculum (3), and organizations investigated (3). The numbers in brackets indicate frequency of cases.

We can conclude from the case summaries that public databases, advisors, curriculum, and organizations investigated the most relevant or useful information sources. The answer to the research question about why and in which way cited information sources contribute to the outcome of work tasks: Subject and treatment/orientation.

The connection between the individual information seeker *and* the social or institutional environment during the process of problem solving in the cognitive sociology framework is confirmed in the application of the information sources mentioned above: Advisors, curriculum, and organizations investigated. The information seeker also searches independently as measured by the extensive application of the information source type: Public database.

The main findings of the qualitative part with individual case summary are stated below (table 13).

Case	Relevance criteria	Search tactic	Information source
1	subject treatment/orientation	keyword browsing	public databases
2	subject	advice	advisors
3	subject treatment/orientation	advice	advisors public databases
4	subject	keyword	public databases
5	treatment/orientation	browsing	curriculum
6	subject treatment/orientation	keyword browsing	public databases curriculum organizations investigated
7	treatment/orientation subject	keyword	public databases advisors
8	treatment/orientation subject	browsing	citations homepages
9	subject	keyword	public database
10	treatment/orientation	browsing keyword	public database advisors
11	subject treatment/orientation	browsing keyword	public database
12	treatment/orientation	keyword	public database citations
13	treatment/orientation	browsing	organizations investigated curriculum advisors
14	subject treatment/orientation	browsing	citations organizations investigated

authority
communication
currency

Table 13: Individual case summaries from qualitative part

Information source types:

1. Curriculum: Mandatory or supplementary
2. Proposed by advisors
3. Literature citations
4. Homepages (URL) found by the participant on the internet. Not human edited databases
5. Public databases: Bibliographic, full text, numeric, and directories or dictionaries. Not source 3
6. Personal information sources in the investigated organizations. Name and position of person. Relation to participants' work task.
7. Written information sources in the investigated organizations

5.1.2 Coverage of the existing knowledge of the work task

The average of the 13 cases whose participants had allowed judgment by their supervisor of the coverage of the existing knowledge of their work task showed a high value of 4,4 out of maximum 5. The lowest value was 3 which only counted once. The top end of the judgment was equally spread between 4 and 5 with each representing 6 cases. One case wished not to be part of the supervisor judgment.

The self selection of participants would bias towards the higher end of the values reflecting the most confident and efficacious graduate students willing to participate in the research.

The qualitative judgment allowed space for explaining the supervisor's quantitative judgment. This part of the evaluation was not mandatory but the supervisors were encouraged to comment with a short paragraph. The majority of supervisors choose to add a brief comment. In order to ensure the confidentiality of the participants and supervisors the full extent of the comments is not disclosed but significant clues of the cases:

(ID 1) 'Thorough listing', 'some older but still relevant material'

(ID 2) 'Tightly focused review', 'excellent focus on specifically relevant literature on [work task domain], 'wider context should have been set for the specific focus'

(ID 3) 'Good'

(ID 4) 'Quality of the bibliography isn't always a good indicator of the quality of the literature review'

(ID 5) 'Very satisfactory list', 'personal correspondence with some of the people involved'

(ID 6) 'Good mixture of relevant types of material', 'appropriate for the literature in the fields [ID 6] covers', 'key topic areas are represented', 'appropriately up-to-date', 'cited carefully, consistently and fully'

(ID 7) 'Very thorough and relevant for the topic'

(ID 8) 'Good coverage regarding methodology and the area of research', 'just one or two gaps'

(ID 9) 'Careful to select and examine references that were relevant to [x] research question in a way that was as objective as possible'

(ID 10) 'Expected the bibliography not to be comprehensive but rather selective in citing items representative of the coverage of the diverse aspects of the topic', 'quantitative judgment is more in terms of representative coverage rather than absolute numbers. My qualitative judgment on the 'relevance of citations is equally very high', 'balance between both theory and practice', 'discussion papers and empirical case studies', 'specific techniques and the broader

context', 'appropriate period of time'; 'different methodological approaches', 'case studies from different countries'

(ID 11) 'Outstanding piece of work', 'principal relevant policy documents and critiques', 'sufficient theoretical material to enable [ID 11] to develop a theoretically informed analysis of [ID 11]'s empirical work, 'adequate to the task, and certainly covered the principal texts relating to the chosen policy area', 'had guidance'

The ID numbering is rearranged for this section.

Recurrent keywords are 'currency', 'comprehensive/thorough', 'focused/selected', 'appropriate/relevant', and 'treatment/orientation'.

In general, the external evaluation of the final product shows a very satisfactory view of the coverage of the existing knowledge of the work task.

The extent of guidance of the supervisor to cover the existing knowledge in a satisfactory way is only revealed in one case mentioned above: "had guidance". In the remaining cases we must assume an agreement (tacit or explicit) between the participants and their peers about what is 'satisfactory coverage of the existing knowledge' in the work task at hand since the evaluations are significant positive.

5.2 Quantitative part

This part investigates the similar basic research question as the qualitative part; apart from that there is no external evaluation by examiners of the participant's work task. The evaluation of the information source types and relevance criteria were on an aggregated level while the qualitative part evaluated on an individual level (each reference).

The duration of the dissertation work was 3-6 months. There might have been an overlap when the regular coursework was finished at the same time as the preparation of the dissertation work. Extension of the dissertation deadline was maximum 2 months in the sample. The data is summarized below (table 14).

5.2.1. Problem solving stages

The 4 problem solving stages 'problem recognition', 'problem definition', 'problem resolution', and 'solution statement' are assumed in the research model to develop either 'separately', 'sequentially', 'overlapping', or 'iteratively'.

The development between the pairs of stages results in 5 different combinations:

1. 1. Problem recognition: Kind of problem
2. Problem definition: Nature of the problem
2. 2. Problem definition: Nature of the problem
3. Problem resolution: Finding an answer to the problem
3. 3. Problem resolution: Finding an answer to the problem
4. Solution statement: An answer to the problem or how to deal with it
4. 1. Problem recognition: Kind of problem
4. Solution statement: An answer to the problem or how to deal with it
5. 2. Problem definition: Kind of problem
4. Solution statement: An answer to the problem or how to deal with it

We tested the following hypotheses:

1. High distance in problem solving stage pairs (difference ≥ 2) results on average in a high probability of problem solving stage pairs occurring “separately” (high mean).
2. High means of all problem solving stage pairs that occurred ‘sequentially’ results on average in a constantly progressing resolution of the work task without significant barriers, ‘anomalous state of knowledge’ (Belkin, Oddy; and Brooks,1982) or redefinition of the basic work task problem.
3. In the research model of the information seeking process we test the dynamic development to reduce uncertainty or increase value through the 4 stages until the problem is solved: If uncertainty fails to be resolved at any one stage, it may result in a feedback loop to a previous stage for further resolution. The problem-solving process is seen as an iterative development. If the stage development is highly dynamic we expect high average values of ‘overlapping’ and ‘iterative’ problem solving stage types.

Result of the hypothesis testing:

1. For pair 4 (1. problem recognition - 4. solution statement) there is a slight confirmation of the hypothesis. The means that the problem solving stage pairs occurred ‘separately’ (2,50), ‘sequentially’ (2,83), and ‘iteratively’ (2,77), while the expected least agreement was for ‘overlapping’ (3,12). The result is not significant for pair 5 (2. problem definition – 4. solution statement) since the means vary only between 2,70-2,92.

2. The problem solving stage pairs that occurred ‘sequentially’ resulted on average in a constantly progressing resolution of the work task:. The results for the pairs:

Pair 1 (1. problem recognition - 2. problem definition): 3,17

Pair 2 (2. problem definition - 3. problem resolution): 3,10

Pair 3 (3. problem resolution - 4. solution statement): 2,80

Pair 4 (1. problem recognition - 4. solution statement): 2,83

Pair 5 (2. problem definition - 4. solution statement): 2,92

The hypothesis can be rejected since all the means are not close to 1 (‘strongly agree’).

3. The merged ‘overlapping’ and ‘iteratively’ problem solving stage types resulted on average in the 5 pairs:

Pair 1 (1. problem recognition - 2. problem definition): 2,44

Pair 2 (2. problem definition - 3. problem resolution): 2,53

Pair 3 (3. problem resolution - 4. solution statement): 2,59

Pair 4 (1. problem recognition - 4. solution statement): 2,95

Pair 5 (2. problem definition - 4. solution statement): 2,83

We can conclude that the overlapping and iteratively character of the problem solving stage developments is present but only to a moderately extent. We can therefore confirm the 3rd hypothesis.

Variable	\bar{x}	SD
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No Name

Problem stages

1	1. Problem recognition: Kind of problem		
	2. Problem definition: Nature of the problem		
	Separately	3,14	1,22
	Sequentially	3,17	1,12
	Overlapping	2,60	1,14
	Iteratively	2,27	0,95
2	2. Problem definition: Nature of the problem		
	3. Problem resolution: Finding an answer to the problem		
	Separately	2,90	1,26
	Sequentially	3,10	1,10
	Overlapping	2,53	1,10
	Iteratively	2,52	1,07
3	3. Problem resolution: Finding an answer to the problem		
	4. Solution statement: An answer to the problem or how to deal with it		
	Separately	3,37	1,09
	Sequentially	2,80	1,16
	Overlapping	2,60	1,12
	Iteratively	2,58	1,09
4	1. Problem recognition: Kind of problem		
	4. Solution statement: An answer to the problem or how to deal with it		
	Separately	2,50	1,21
	Sequentially	2,83	1,20
	Overlapping	3,12	1,14
	Iteratively	2,77	1,11
5	2. Problem definition: Kind of problem		
	4. Solution statement: An answer to the problem or how to deal with it		
	Separately	2,70	1,21
	Sequentially	2,92	1,15
	Overlapping	2,88	1,11
	Iteratively	2,78	0,94

Uncertainty at each stage of work task

6	1. Problem recognition: Kind of problem	2,70	1,09
7	2. Problem definition: Nature of the problem	2,93	0,88
8	3. Problem resolution: Finding an answer to the problem	2,93	0,92
9	4. Solution statement: An answer to the problem or how to deal with it	2,87	1,10

Most important information source type

10	Curriculum (reading lists from present or previous course work)	2,50	1,21
11	Information proposed by advisors (supervisors, students)	3,35	1,27
12	Literature citations (references in books, journals, or homepages)	3,93	1,13
13	Homepage (webpages but not general search engine or gateway)	2,52	1,28
14	Public database (text documents, images, statistics, not general search engine)	3,00	1,35
15	Printed directory or dictionary	1,95	1,06
16	Organizations investigated (interviews, discussions, observations, correspondence)	3,83	1,39

Relevance criteria

17	Subject (general-specific, central-tangential)	4,12	1,03
18	Treatment/orientation (theoretical, practical, discussing, descriptive)	3,53	1,02
19	Currency (new, redundant, or outdated knowledge)	3,42	1,12
20	Authority (central person or institution)	3,42	1,12
21	Communication (difficult or easy comprehensible)	2,92	1,03
22	Geography (location)	2,48	1,27
23	Population (sample in work task - ex. age, gender, and occupation)	2,57	1,42

Solution statement: An answer to the problem or how to deal with it		
24	Increased value of work task	2,08 0,72
25	Reduced uncertainty of work task	2,15 0,97

Table 14: Problem solving stages, information sources, and relevance criteria

n=60. Variable 1-5, 24-25: Strongly agree (1), agree (2), unsure (3), disagree (4), strongly disagree (5). Variable 6-9: Highest uncertainty (5). Variable 10-16, 17-23: Highest rank (5)

In the research model the information seeking process is seen as a dynamic development to reduce uncertainty through 4 stages until the problem is solved:

1. Problem recognition: Kind of problem.
2. Problem definition: Nature of the problem.
3. Problem resolution: Finding an answer to the problem.
4. Solution statement: An answer to the problem or how to deal with the problem.

If uncertainty fails to be resolved at any one stage, it may result in a feedback loop to a previous stage for further resolution. The problem-solving process is seen as an iterative development. The hypothesis derived from the research model:

uncertainty stage = 1 → uncertainty level = \bar{x}

uncertainty stage = 2 → uncertainty level = \bar{x} - factor p

uncertainty stage = 3 → uncertainty level = \bar{x} - factor p x 2

uncertainty stage = 4 → uncertainty level = \bar{x} - factor p x 3 (assuming work task is solved)

The results showed a surprising progress of the uncertainty stages. The hypothesis can be rejected since there is no significant decrease in uncertainty level from stage 1 to 4. The maximum difference between the stages is 0,23 on the 5-point scale (5=highest uncertainty). The development through the stages is 2,70 - 2,93 - 2,93 - 2,87. We can also conclude that the large 2/3 majority solved their work tasks with a satisfactory uncertainty level since only 31,6 % “disagree-strongly disagree” for the stage 4: ‘solution statement: An answer to the problem or how to deal with it’. The surprising finding is a rejection of previous research by Kuhlthau (2003). There is no resolution of the uncertainty and it is not particular high at the beginning of the information seeking process.

When we focus on stage 4: ‘solution statement: An answer to the problem or how to deal with it’ we found that the participants on average agreed that they ‘increased the value of their work task’ (2,08) or ‘reduced the uncertainty of their work task’ (2,15). The frequency distribution for these two variables are left skewed (figure 15).

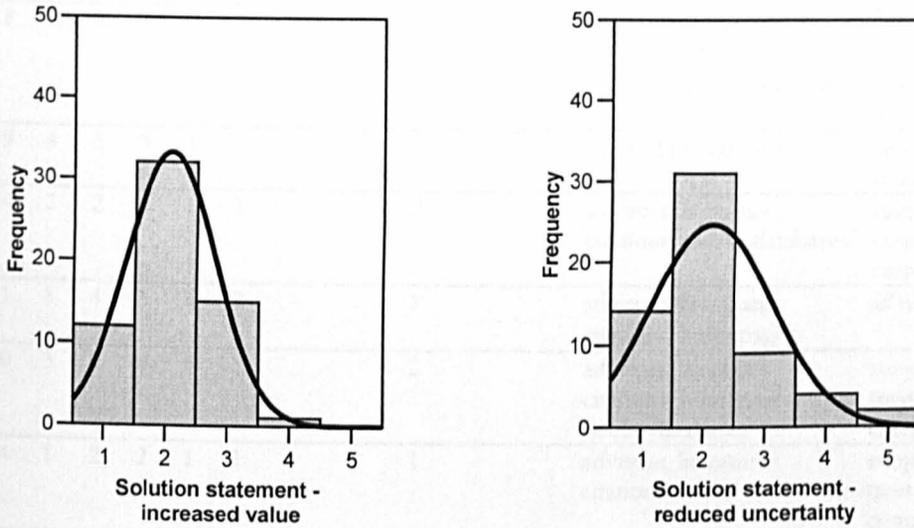


Figure 15: Frequency distribution for problem solving stage 4

n=60. Strongly agree (1), agree (2), unsure (3), disagree (4), strongly disagree (5).

There is no linear or curve linear relationship between the 'increased value' and 'reduced uncertainty' variables.

We investigated the individual observations with the highest successful final product, i.e. which are distant from the mean. This is measured as either/both highly reduced uncertainty (value=1) or highly increased value (value=1) at the crucial stage 4: Solution statement. We conclude that the participants did not need to have an either high or low starting point to end with a successful outcome, i.e. increased the value significantly in the outcome of the work task. The same individual cases are displayed for a significant choice of information sources (value=4-5) and relevance criteria (value=4-5). We see that the pattern is consistent with the general findings of the whole sample: No correlations between relevance criteria, information sources and the final work resulted in increased value or/and uncertainty reduction. The typical successful information seeker emphasized literature citations, advisors, organizations investigated, homepages, and public databases. He judged according to the subject matter, currency, treatment/orientation, and authority (table 16).

ID	Uncertainty at each stage of work task variable 6-9				Increased value of work task variable 43, value=1	Reduced uncertainty of work task variable 44, value=1	Information source value=4-5	Relevance criteria value=4-5
	1	2	3	4				
1	5	4	3	1	1	1	literature citations	currency
2	4	3	2	2	1	1	advisors, homepages, organizations investigated	subject, treatment/orientation, communication
10	2	3	3	3	1	1	organizations investigated	currency, authority, population
15	4	3	2	1	1	1	curriculum, advisors, literature citations, public databases	subject, authority
17	2	2	2	1	1	1	homepages, organizations investigated	subject, currency, authority, communication

18	2	3	3	2	1	2	Literature citations, public databases, organizations investigated	subject, treatment/orientation, currency, geography, population
19	4	3	3	1	1	1	curriculum, advisors	subject, treatment/orientation
24	2	2	1	1	1	2	advisors, literature citations, public databases	subject, treatment/orientation, currency, authority
31	3	4	3	4	2	1	advisors, literature citations, homepages	<i>all values < 4</i>
40	3	2	4	3	1	2	advisors, literature citations, homepages, public databases	subject, treatment/orientation, currency, authority
44	1	2	2	1	1	1	advisors, literature citations	subject, treatment/orientation, communication, geography
45	3	4	4	3	2	1	literature citations, organizations investigated	subject, currency
47	2	2	4	4	2	1	literature citations, homepages, public databases, organizations investigated	subject, currency, geography
58	4	2	2	1	2	1	advisors, literature citations, organizations investigated	subject, currency

Table 16: Detecting for outliers with highest successful final product

Increased value of work task (variable 43, value=1) or reduced uncertainty of work task (variable 44, value=1). Each case ID is displayed with its significant choice of information sources (value=4-5) and significant relevance criteria (value=4-5).

The information source types were broadly dispersed among the participants regardless of the origin of the participants.

The hypothesis about the existing connection between the individual information seeker and the social or organizational environment is measured by the importance of 3 information source types (highest rank=5):

Curriculum (reading lists from present or previous course work): 2,50

Information proposed by advisors (supervisors, students): 3,35

Organizations investigated (interviews, observations, correspondence): 3,83

The results confirmed that there is an importance of the social and organizational environment but the information source types 'literature citations' (references in books, journals, or homepages) (3,93), 'homepage' (webpages but not general search engine or gateway) (2,52), and 'public database' (text documents, images, statistics, not general search engine) (3,00) are important as well. The information source type 'printed directory or dictionary' (1,95) was of minor importance since the work tasks were complex and not with predefined narrow research questions, i.e. not pure tasks of verification and concept definition.

The relevance criteria, which are applied when selecting information sources for the work task, showed a broad usage of criteria with 'subject' (general-specific, central-tangential) (4,12) as the most dominating (highest rank=5) which was not surprising according to the

user-driven relevance research (Schamber, 1991; Park, 1993; Barry, 1994; White and Wang, 1997).

'Treatment/orientation' (theoretical, practical, discussing, descriptive) (3,53) was the second most preferred relevance criterium. Below follows at the same level of 3,42 'authority' (central persons or institution) and 'currency' (new, redundant, or outdated knowledge). At the bottom of the relevance criteria ranking is 'communication' (difficult or easy comprehensible) (2,92), 'population' (sample in work task - ex. age, gender, and occupation) (2,57), and 'geography' (location) (2,48).

The importance of 'authority' can confirm the hypothesis of the influence on the social or organization environment (Berger and Luckmann, 1966; Fuchs, 1992; Zerubavel, 1997; Choo, 2005; Hedström, 2005).

The comparison of the problem solving stages and 'increased value/reduced uncertainty' in the final work for problem solving stage 4 'solution statement' showed no correlations in either of the five problem solving stage pairs.

There were also no correlations between 'increased value of work task' for problem solving stage 4 'solution statement' and all the information source types.

6. Conclusion

The conclusion is based on the first qualitative part (n=14) and the second quantitative part (n=60). The two parts complement each other. The first qualitative part is able to explore and question in detail central elements of the research problems. The second quantitative part is able to provide a more robust, generic, and validated test of the hypotheses and mechanisms in the research questions. The samples in the two parts share the same attributes: Full-time master dissertation students from the University of Sheffield at different social science and science domains enrolled in the period 2002-2006. The qualitative part used the domains leisure management, town and regional planning, and information management. The quantitative part used the domains engineering, medicine, and information management.

The most significant empirical results from the *quantitative* part were that uncertainty did not reduce it to a very low level and the value increase were not high throughout the process when the information seekers solved complex work tasks. A broad set of information sources were used of both personal and non-personal character. The most important relevance criteria were 'subject' (general-specific, central-tangential), 'treatment/orientation', 'authority', and 'currency'. The criteria confirmed user-driven relevance research (Schamber, 1991; Park, 1993; Barry, 1994; White and Wang, 1997).

The most significant empirical results from the *qualitative* part were that 1/3 of the information sources necessary to create a satisfactory final product was found by independent database searching. The influence from the knowledge community, categorized as institutional factors, attributes for about 1/4 of the most important information sources. Those sources consisted of the curriculum and were recommended by advisors. If the influence from the organizations investigated are included in the institutional factors, the overall share amounts for 1/3 of the most useful information sources. Literature citations had a firm and significant influence but accounted for only 15,2 % of the most important information sources. Homepages had an unimportant role of only 4,6 % among the most important information sources for the work task.

The research result summary is displayed below (table 17).

<i>Social mechanism</i>				
Belief	Variable	Value	Scale	Conclusion
How information sources contribute to the actor's work task	Curriculum	2,50	Highest rank =5	Broadly dispersed application of information sources
	Advisors	3,35		
	Literature citations	3,93		
	Homepages	2,52		
	Public databases	3,00		
	Organizations investigated	3,83		
Relation between individual actor and social or organizational environment	Information sources	Individual: Literature citations (3,93) Public databases (3,00) Homepages (2,52) $\bar{x} = 3,15$	Highest rank =5	Individual \approx social or organizational environment
		Social: Organizations (3,83) Advisors (3,35) Curriculum (2,50) $\bar{x} = 3,23$		
	Relevance criteria	Individual: Subject (4,12) Treatment/orientation (3,53) Currency (3,42) Communication (2,92) Population (2,57) Geography (2,48)	Highest rank =5	Individual \approx social or organizational environment
Problem resolution proceeds in stages by reducing uncertainty or increasing value at each stage until a resolution of the problem is reached	1. Problem recognition: Type of problem	2,70	Highest uncertainty =5	The work task was without ambiguity=1 It was very unclear=5
	2. Problem definition: Nature of the problem	2,93		

3. Problem resolution: Finding an answer to the problem	2,93	
4. Solution statement: An answer to the problem or how to deal with it	2,87	
	Stage 4 \approx stage 1	Rejected
	Stage 4 \approx stage 2	
	Stage 4 \approx stage 3	
Problem solving stages develop either separately, sequentially, overlapping, or iteratively		Rejection of progressing resolution of the work task in stages Moderately overlapping and iteratively problem solving stage developments

Table 17: Research result summary

Limitations

The research model and outcome for the central factors should be interpreted within an integrated cognitive sociology framework. Not all the factors of the research model are possible to describe, analyze, and verify to the same depth. The methodology has been designed to follow sound-scientific principles of verifiability to be able to repeat the methodology (quantitative part). Since the methodology follows a mixed methods direction, any repeated adoption of the research model will need adoptions depending on the available population, sample, and cooperativeness of stakeholders. Furthermore, organizational context and time frame conditions will set a boundary for any future work.

Limitations for the most central factors:

Actors

The information seekers chosen in the combined quantitative and qualitative sample of graduate full time dissertation students solving a complex independent work task from a variety of domains in social science, IT, and medicine have been aimed to reduce limitations of the generalizable matter of the results. Furthermore, different department and institutions participated which reduces the institutional bias. There was a possibility of bias in the sample which was due to the voluntary participation. There was not found any directly measured bias which could significantly affect the main conclusions. The participants did not all show high levels in reduced uncertainty or increased value of the work task. This key result rejected bias that only highly confident dissertation students from the sample choose to participate. The low response rate in some domains in the potential sample was not anticipated and optimal, but the prolonged engagement of engaging additional subject domains and institutions have compensated for this factor. The

methodology has been designed to be able for the research community to extend the survey methods for other samples with different characteristics of domains, institutions, and geography.

Increasing value of work task

The increasing value concept follows in tandem with the reduction of uncertainty concept as displayed in the research model. The value is the information seekers' subjective interpretation and it is relative to his development of the problem solving stages for his work task. It has been possible to measure this in the survey.

Reduction of uncertainty of work task

The concept of uncertainty is more elusive than the value concept, but it is as important to measure as its counterpart increasing value.

The concept is applied in different settings and under different theoretical frameworks, for example game theory, investment theory, and cognitive psychology. It is important to state that a narrow interpretation of the uncertainty concept to encompass purely mental states about feelings without coupling to actions, work tasks, and organizational conditions will remove the substance of the concept. The present research has revealed the difficulties the information seekers had to express in the uncertainty development throughout the problem solving stages. The empirical problems should not prevent us from staying on the track and develop refined theoretical models and methodologies to solve the puzzle. Applying game theory is a promising direction which has crucial impact in real world situations for judgment and decision making. There is still a way to pass before the field is fully mature and developed, not least escaping the narrow world of artificial laboratory simulations.

Information sources

It is complex to integrate all types of information sources to solve real world work tasks in one research design. It is nevertheless necessary if information science shall be able to develop a comprehensive social theory-based understanding of information seeking. We have unfortunately fragmented sub-domains (Ingwersen and Järvelin, 2005) which each have their limited agenda. For example, the domain 'information behavior' produce significant and wide spanning research, but often the outcome is limited to a narrow type of institutions, a specialist actor group, or only a few types of available information source types are investigated. Furthermore, often only a fraction of the problem solving stages is followed. For example, the information seeker's search queries are not directly related to the final product of the work task. The present research attempts to overcome these limitations.

Usefulness

The concept of usefulness is a well-researched subject in information science. Hence, it has not given significant problems in the present research. We used a 5-point Likert scale to measure the extent of usefulness on the individual cited references for each work task in the qualitative part and measured on a generic level for each information source type.

Relevance criteria

The history of relevance has a long and very substantial base in information science (Saracevic, 2007a,b). In the qualitative part the information seekers were able to apply the core relevance after a brief introduction during the think aloud procedures at the

information seeker's computer. In the quantitative part a subset of potential information seekers were given a pilot version which led to a few clarifying definitions and examples of how to apply the core relevance criteria.

Problem solving stages

This factor was the most difficult to understand for the information seekers. The present research application of the four stages was a thorough test of Kuhlthau's (1993) and Wilson's (1999) information seeking models.

Unfortunately, it was not possible to detect any significant correlations between this factor and the relevance criteria, information sources, value increase, or uncertainty reduction. The reason for the lack of correlations could be that (1) the variables are simply working independently of the other variables, or (2) there are exogenic factors affecting the problem solving stages not accounted for in the quantitative and qualitative research model. It was not possible to detect any additional variables affecting the problem solving stage development based on the information seekers' utterances. Although we have substantial knowledge of judgment and decision making (Hogarth, 1987, Brunsson, 2007) as well as cognitive work task analysis (Crandall, Klein, and Hoffman, 2006) for solving complex work tasks, we are still confronted with the need to develop better tools and methodologies to accurately capture the internal cognitive processes during the problem solving process towards an increased value and reduced uncertainty for the final product of the work task.

Contribution

In the accumulative process of research in information science the aim for the present research is to contribute to the enhancement of an integrated understanding and application of information seeking.

When considering what was previously missing in information seeking, I rank the following factors in decreasing order of contribution:

1. Longitudinal study in information seeking of the work task from initiation to the final product applying all types of available information sources.
2. Cognitive work task analysis in an organizational and social theory framework.
3. Application and validation of the core relevance criteria.

Application of theoretical and methodological model

The cognitive sociology model based on Berger and Luckmann (1966) and Zerubavel (1997) proved to be applicable for the performance and understanding of the empirical data. Information science in a cognitive sociology framework enhances the understanding of the social mechanism relation between the individual and social influences of information seeking. The information source types and relevance criteria applied were constructive. The cognitive sociology model with its institutional focus can be applied in all domains and different institutional environments as well as with different kinds of information sources.

The methodology of the cognitive sociology model was realizable and appropriate for the sample and the empirical data. Triangulation was integrated in the research design with the external evaluation of the final work product to obtain a different viewpoint of the outcome of the work task. There was a possible bias in the qualitative sample which was due to the voluntary participation. There was not found any directly measured bias which could significantly affect the main conclusions. The participants did not all show high levels

in reduced uncertainty or increased value of the work task. This key result rejected bias that only highly confident dissertation students from the sample choose to participate. The quantitative sample size did not show any strong bi-correlations.

The combination of qualitative and quantitative measures as reviewed in Tashakkori and Teddlie (1998) proved fruitful and complemented each other. The case reports provided a focus and clarification of the following quantitative measures of the research questions.

7. Implications for future research

The implications for future research are to consider a cognitive sociology viewpoint on the information seeking process. When possible, it is recommended to encompass the entire problem solving stages of the work task from problem recognition to solution statement. The information seeking process for complex work tasks without a predefined method and solution requires different search tactics, information source types, and relevance criteria. The IT development and international standards implementation (World Wide Web Consortium, 2008) enables members of profit- and non-profit-based organizations to instantly and dynamic search and retrieve knowledge sources regardless of vendors, locations, document formats, media types, platforms, networks, and physical device. This international development expands the scope for the present research's theoretical and methods to accommodate future integrated heterogeneous information network environment.

Cognitive task analysis

Cognitive sociology for information seeking can be incorporated as one aspect of a broader framework in cognitive task analysis (Crandall, Klein, and Hoffman, 2006, p. 245-257). This approach focuses on individual and team work task strategies in real world contexts to understand the reasoning and decision making.

The applications of the systematic framework in cognitive task analysis within an organizational understanding are diverse and can be mission critical for the organizations in which the work tasks are being solved. For example, the areas covered can be:

Information system development: A comprehensive understanding of the actors' decision making and strategies to optimize the utilization of the tools and the content of the information systems. The purposes are to facilitate both subject matter experts (extracting tacit knowledge) and novices. The usability approach is a subfield of cognitive task analysis applying the cognitive engineering theories (Rasmussen, Pejtersen, and Goodstein, 1994).

Training: Particularly on-the-job training can improve instructional practice by having the trainee taking an active role in the process "even directing the process by probing the subject matter expert". The cognitive task analysis can help subject matter experts articulate the subtle aspects of their expertise in on-the-job settings and having the trainees learn to ask better questions.

Organizational design: Team-based cognitive task analysis can improve understanding of how organizations assign tasks to improve coordination.

Market research: Cognitive task analysis focus on what consumer's know, how they think, and their developed strategies for buying and using products. The analysis provides the reasoning for purchasing particular product, brand, and their features. Furthermore, the product developers and the sales employees may use the corporation's products or services in other ways than anticipated. Within the information seeking field we can for example measure and analyze the problem recognition and formulation, problem resolution (search tactics and search results) when a consumer needs to purchase a new cell phone on the market. This work task may encompass previous own experience, virtual inspection on

product offerings from online inventories, physical inspection, personal recommendations, public advertisement, and independent consumer guides.

Network

The cognitive sociology approach can be extended to the level of network analysis and representation (Carrington, Scott, and Wasserman, 2005; Thelwall, Vaughan, and Björneborn, 2005). The definition of a network originates from graph theory (Diestel, 2006). “Nodes (vertices) identify the elements of the system. The set of connecting links (edges) represents the presence of a relation or interaction among these elements” (Caldarelli and Vespignani, 2007, p. 5).

V	Set of vertices.
E	Set of edges.
G	Graph of vertices (points) connected by edges (lines).
n	Graph $G(V,E)$ V has order n when V has n vertices.
M	Size of the graph is the number m of its edges.
Incident	Edge e links vertices v_1, v_2 .
Adjacent	Vertices v_1, v_2 joined by edge e are neighbors.
Dominating set	Set of vertices whose neighbors and themselves constitute all the vertices in the graph.
Directed	Graph $G(V,E)$ by two disjoint sets E and V plus two functions $I(E \rightarrow V)$ $F(E \rightarrow V)$. The 1 st assigns every edge e an initial vertex $I(e)$. The 2 nd assigns every edge e a final vertex $F(e)$. If $I(e)$ and $F(e)$ coincide e is a <i>loop</i> .
Subgraph	We have 2 graphs: $G(V,E)$ and $G'(V',E')$. A new graph is indicated by $G \cap G'$ whose vertices are in the set $V \cap V'$ and the edges in the set $E \cap E'$. If $V \cap V' = \emptyset$ the 2 graphs are disjoint. If $V' \subseteq V$ and $E' \subseteq E$ then $G'(V', E')$ is an induced subgraph of $G(V,E)$: $G'(V', E') \subseteq G(V,E)$. If $G'(V', E') \subseteq G(V,E)$ and $V'=V$, $G'(V', E')$ is spanning of $G(V,E)$.
Degree	Number of edges in vertex v_i - $k(v_i)$. A weighted graph $k_w(v_i)$ is the sum of the weight of the edges on v_i . The degree can be either: in-degree $K^{in}(v_i)$: Number of incoming edges to a vertex. out-degree $K^{out}(v_i)$: Number of outgoing edges to a vertex.
Path of consecutive edges	Graph $G'(V',E')$ of the form $V' = v_0, v_1, \dots, v_n$, $E' = e_1, \dots, E_n$ where v_0, v_1, \dots, v_n is a set of vertices for which e_i is an edge joining vertices v_{i-1} and v_i .
Path of series connectivity	Exist between any couple of vertices v_i, v_j in a graph.
Tree	Connected graph without cycles. Vertices (degree=1) in a tree are <i>leaves</i> . One vertex of the tree can be considered <i>root</i> . A tree with a fixed root is a rooted tree .
Clustering	Cliques in the neighborhood of any given vertex. High clustering implies that if vertex i is connected to j , and j is connected to l , then very likely i is also connected to l .

Figure 18: Definition of basic graph elements

The information source types applied in the present research can be modeled in the network theory as vertices each coded for its particular type of information source and each vertex has a unique instance of the information source. The edges represent the relations in the information seeking process towards solving the work task. In the present research the weights of the edges is measured by its usefulness (scale: 1-5). The attributes of the edges are in the present research operationalized by the core relevance criteria. The agents (Hedström, 2005), who carry out the work task individually or in a team as a member of an organization, can be considered a root vertex (anchor node) when the

network analysis is viewed from the perspective of the organization's actors. The critically cognitive sociology approach understands the agents as stakeholders and with conflicting interests competing for limited resources (tangible and intangible).

The network is dynamic as the work task of the agents evolves. The total network size can expand or scrimp. The internal structure and attributes may be modified according to changes over time of weights attached to the edges between the vertices. The density of the network may also alter as the clustering process is developing. The directions of the edges between the vertices changes as the communication (direct and indirect interactions) between the agents and the information sources evolve.

The vertices are preferentially connected to other vertices with similar degree. This network type is assortative in contrast to disassortative network when vertices are preferentially connected to other vertices with very different degree, a.e. biological and technological networks.

The directions of the edges to its vertices can be specified but in the present research this aspect falls outside the research question. The analysis of directions coupled with its clusters (cliques in the neighborhood of a vertex) is of high importance in social network theory, a.e. citation analysis and knowledge communities. Furthermore, production logistics, utilities, traffic infrastructures, and systems design benefit from network theory. An overview of central definitions in graph theory (Caldarelli and Vespignani, 2007, p. 6-12) is provided (table 18) and application of the present research model to a network approach for a given work task in one time frame for a set of agents who are members of an institution (figure 19). Each agent (vertice) is connected by edges representing a relevance criteria with a given weight depending of the usefulness level. The edges are linked to nodes representing particular information sources (types and instances) as defined in the present research. No rules for interaction, directions, and thresholds (total network limit, number of agents, and connection parameters) are defined in the example but to aid the reading of the figure the point of direction is from the agent.

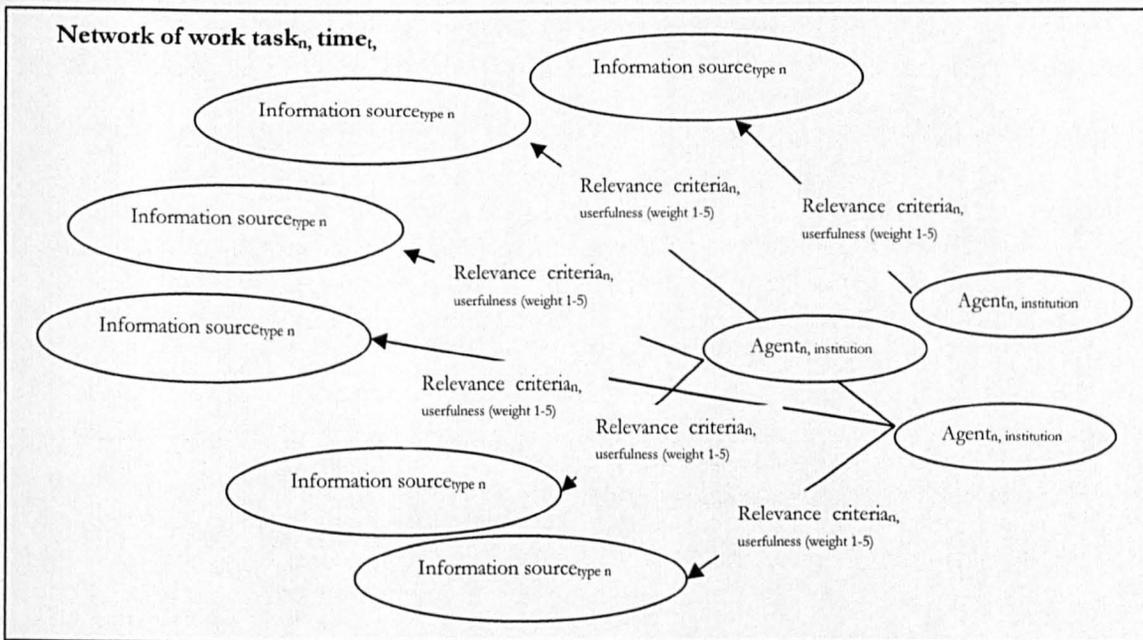


Figure 19: Network representation for the basic elements of the research model

In the example from the present research model we can consider each cited reference of the agent's final product as a sub-graph of the agent's own work. This interpretation of sub-graph is anticipating all types of information source types regardless of its particular physical and conceptual form.

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Online Case Form

Appendices

Record card

Start date of work task

Approximate date of work task

Permission by student to obtain information by its supervisor about coverage of existing knowledge

Supervisor and session date

Coverage of existing knowledge by final product: 1-5

Comments of supervisor

Work task

Level

Class

Global

Issue

Description

Work task context

Problem-solving stages

1. Problem Recognition: Kind of problem

2. Problem Definition: Nature of problem

3. Perceived constraints: Funding sources, information

4. Self-set statement: Answer to problem or how needed to fix it

Information sources

Type

Levels

Homepage

Database

Name

Search engine

Topic

Printed materials and documents

Name

Search engine

Topic

Organizations

Parents: Title and function

1. Office location

Divisions

Topic

1

1. System

1. Author

2. Subject

2. Document

1. Author

2. Subject

Final work

1. Reference usefulness level 1-5 2. Areas covered 3. Areas not covered 4. Areas not covered 5. Areas not covered

Comments: 1. About 2. Information 3. Source

Notes: 1. About 2. Information 3. Source 4. Areas covered 5. Areas not covered 6. Areas not covered 7. Areas not covered 8. Areas not covered 9. Areas not covered 10. Areas not covered

Online case form

Participant ID _____ Supervisor ID _____
 Record date _____
 Start date of work task _____ Submission date of work task _____
 Permission by student to obtain information from supervisor about coverage of existing knowledge: yes/no
 Supervisor submission date _____
 Coverage of existing knowledge in final product (1-5) _____
 Comments of supervisor _____

Work task

Level	Clue
-------	------

Global

State

Organization

Work task activity

Problem solving stages

1. Problem Recognition: Kind of problem
2. Problem Definition: Nature of problem
3. Problem Resolution: Finding answer to problem
4. Solution Statement: Answer to problem or how to deal with it

Information sources

Type	Result
------	--------

Homepages

Databases

Name

Search reason

Tactic

Printed directories and dictionaries

Name

Search reason

Tactic

Organizations

Persons: Title and function

Contact reason

Documents

Tactic	n	%
--------	---	---

1. Systemic

1. Author

2. Subject

2. Browsing

1. Author

2. Subject

Final work

n	reference	usefulness	used how	criteria	found how	search tactic	source format	source type
---	-----------	------------	----------	----------	-----------	---------------	---------------	-------------

Usefulness: (2) slightly, (3) middle, (4) quite, (5) totally.

Information source type: (1) curriculum, (2) proposed by advisors, (3) literature citations, (4) homepage, (5) public database, (6) printed directory or dictionary, (7) organizations investigated.

How uncertain did you feel at each stage of this work task?

Online questionnaire

Department

Start date of work task [dissertation]

End date of work task [dissertation]

Work Task [dissertation] *Title of your work task - please state as precise as possible*

Problem solving stages [dissertation]

Please select below if the stages happened separately, sequentially, overlapping, or iteratively. (strongly agree, agree, unsure, disagree, strongly disagree)

1. Problem recognition: Kind of problem [first ideas] - You identify your problem in terms of a broad topic and why it is of interest.
2. Problem definition: Nature of the problem [objectives, attributes] - You define the problem and its elements more precisely in terms of clear research questions.
3. Problem resolution: Finding an answer to problem [searching, testing, writing] - You decide exactly how you will go about solving the problem/answering the research questions in terms of methodology etc.
4. Solution statement: An answer to the problem or how to deal with it [conclusion] - You analyze your data and draw conclusions in an attempt to answer your research questions.

1. Problem recognition: Kind of problem

2. Problem definition: Nature of the problem

1 and 2 happened separately [clearly distinguishable distinct stages]?

1 and 2 happened sequentially [stage 2 began only after stage 1 was completed]?

1 and 2 happened overlapping

1 and 2 happened iteratively [you revisited stage 1 or 2 later in your dissertation work]?

2. Problem definition: Nature of the problem

3. Problem resolution: Finding an answer to the problem

2 and 3 happened separately?

2 and 3 happened sequentially?

2 and 3 happened overlapping?

2 and 3 happened iteratively?

3. Problem resolution: Finding an answer to the problem

4. Solution statement: An answer to the problem or how to deal with it

3 and 4 happened separately?

3 and 4 happened sequentially?

3 and 4 happened overlapping?

3 and 4 happened iteratively?

1. Problem recognition: Kind of problem

4. Solution statement: An answer to the problem or how to deal with it

1 and 4 happened separately?

1 and 4 happened sequentially?

1 and 4 happened overlapping?

1 and 4 happened iteratively?

2. Problem definition: Nature of the problem

4. Solution statement: An answer to the problem or how to deal with it

2 and 4 happened separately?

2 and 4 happened sequentially?

2 and 4 happened overlapping?

2 and 4 happened iteratively?

How uncertain did you were at each stage of your work task?

Highest uncertainty=5 (the work task was without ambiguity=1, it was very unclear=5)

1. Problem recognition: Kind of problem
2. Problem definition: Nature of the problem
3. Problem resolution: Finding an answer to the problem
4. Solution statement: An answer to the problem or how to deal with it

What were your most important information source types.

If two information source types were equally important please assign them equal rank. Highest rank=5

1. Curriculum (reading lists from present or previous course work)
2. Information proposed by advisors (supervisors, students)
3. Literature citations (references in books, journals, or homepages)
4. Homepage (webpages but not general search engine or gateway)
5. Public database (text documents, images, statistics: not general search engine or only in-house database)
6. Printed directory or dictionary
7. Organizations investigated (interviews, discussions, observations, correspondence)

Which relevance criteria did you select for the information sources to your work task?

If more than one relevance criteria were equally important assign them equal rank. Highest rank=5

- Subject (general-specific, central-tangential)
- Treatment/orientation (theoretical/abstract, practical/factual, discussing/analyzing, descriptive/listing)
- Currency (new, redundant, or outdated knowledge)
- Authority (central person(s) or institution)
- Communication (difficult or easy comprehensible)
- Geography (location)
- Population (sample in your work task - ex. age, gender, and occupation)

Problem solving stage 4: Solution statement: An answer to the problem or how to deal with it

(strongly agree, agree, unsure, disagree, strongly disagree)

I increased the value of my work task (your own perception of the outcome of the dissertation)

I reduced my uncertainty of my work task (finished with a clear understanding of the dissertation problem)

Please give your consent

full name

E-mail

Introduction letters to graduate students and supervisors



UNIVERSITY OF SHEFFIELD
DEPARTMENT OF INFORMATION STUDIES

Postal address: Western Bank, Sheffield S10 2TN

Location: Regent Court, 211 Portobello Street, Sheffield S1 4DP

Tel. xx Fax. xx

E-mail: x@x.ac.uk WWW: <http://www.xx.ac.uk>

PH.D. PROJECT
INFORMATION SCIENCE

[date]

Dear graduate student,

I would like to ask for permission to follow your information searching and use in relation to your master's dissertation. The investigation covers the whole period from your first impressions of your master's dissertation to the final product when it is submitted and evaluated. The time limit for the investigation is one year.

Your participation is designed so as not to cause you any inconvenience during your work tasks. There would be no delay for your dissertation and no extra work tasks for you relating to my investigation.

The aim of the investigation is to let you talk about the information sources visited during the information searching for the master dissertation. The information sources comprise the entire range of sources used, for example they may be among those listed below:

- Information sources required as part of the curriculum.
- Information sources proposed by advisers in connection with your work task.
- Literature references.
- Homepages found on the internet.
- Public databases, directories, and dictionaries.
- Personal and written information sources in organizations investigated if you use empirical data.

A brief follow up meeting (1/2 hour to one hour) after submitting the dissertation would consider the cited references in your dissertation. You would be asked to talk about the references which are most useful and why and in what way did the information sources in question contribute to your final product?

You may contact me when you are going to search for information sources of any kind. The location of the information searching may be decided by you depending of what is convenient. If you don't feel it is possible for me to be present during the information searching, please let me know. You may afterwards explain me about the information searching.

The investigation follows the guidelines in the 1998 Data Protection Act from the University of Sheffield. Your data would be kept confidential and your comments anonymized when the data analysis is finished. You have open access to data from your recording and may obtain a copy of the final case report if requested. You may at any time redraw from participation in the investigation.

If you have any questions you are welcome to contact me. I look forward to hear from you.

The investigation is supervised by Nigel Ford, Department of Information Studies, and I obtained approval to contact you from dissertation coordinator (x).

Sincerely,
[researcher]



U N I V E R S I T Y O F S H E F F I E L D
D E P A R T M E N T O F I N F O R M A T I O N S T U D I E S
Postal address: Western Bank, Sheffield S10 2TN
Location: Regent Court, 211 Portobello Street, Sheffield S1 4DP
Tel. xx Fax. xx
E-mail: x@x.ac.uk WWW: http://www.xx.ac.uk

P H . D . P R O J E C T
I N F O R M A T I O N S C I E N C E

[date]

Dear Dissertation Supervisor,

I am pursuing Ph.D. research in the Department of Information Studies 2001-2004. I would like to ask for participation in my Ph.D. project in information seeking and use which I carry out among graduate students writing their master's thesis in your department.

Your contribution would be to provide a validation of existing literature on the subject of the thesis of your present students:

- Quantitative judgment: Do the citations cover the existing literature or knowledge in a satisfactory way (scale: 1-5).
- Qualitative judgment of the citation's relevance for the master's thesis.

The investigation follows the guidelines in the 1998 Data Protection Act from the University of Sheffield. Your data would be kept confidential. Your comments would be anonymized when the data analysis is finished.

You have open access to data from your record and may obtain a copy of the final case report if requested.

If you have any questions you are welcome to contact me. I would be pleased to give you any further information you may wish. I look forward to hearing from you. In particular, if you are willing to help me I would be very grateful if you would contact me either by E-mail or phone (see below).

The investigation is supervised by Nigel Ford, Department of Information Studies, and I obtained approval to contact you from dissertation coordinator (x).

Sincerely,
[researcher]

Oral introduction for participants

I would kindly ask you to talk about the information sources visited during the information searching and the relationship to your master dissertation. You may elaborate without feeling any constraint; your personal views and experience are also welcome.

The session would secure your anonymity. Any data would not be able to be traced back to you personally when the data analysis is finished.

Homepages

Please tell for each homepage visited, why and how you reached it.

If the address of a particular homepage is already known to you, please tell the origin of this knowledge.

Please tell about the usefulness of the homepages. You are welcome to say anything which is brought to your mind when you saw the homepages.

Usefulness scale: 2-5.

Public databases

Please tell why you selected the database.

Please tell why and how you reached the information sources.

Please tell about the usefulness of the search result. You are welcome to say anything which were brought to your mind when you saw the information sources.

Usefulness scale: 2-5.

Personal information sources and documents within organizations investigated

Which personal resources and documents in the organization did you use?

How were the persons contacted?

How were the documents collected?

What was the usefulness of the persons or documents?

Usefulness scale: 2-5.

Description of usefulness scale:

2. Slightly useful
3. Middle useful
4. Quite useful
5. Totally useful