A non-linear model of information sharing practices in academic communities

ABSTRACT

A new model of information sharing practices in academic communities is based on Latour's circulatory system of scientific facts and some elements of Foster's non-linear model of information-seeking behavior. The main proposition of this model is that information sharing practices and context simultaneously shape each other. The proposed model supports Foster's conceptualization of information practices as non-linear processes, but its emphasis on the interdependence between context and information practices provides a more effective means to capture complex negotiations involved in information sharing practices. The proposition is that the major reason for non-linearity in information practices is a continuous shifting of actors' interests, pressures, and concerns. Capturing these dynamic relations becomes possible through this model. The model also offers a way to generate a number of research questions and hypotheses, and as such it could be a useful tool for empirical studies on information sharing in academic communities.

INTRODUCTION

Talja (2002) defines information sharing "as an umbrella concept that covers a wide range of collaboration behaviors from sharing accidentally encountered information to collaborative query formulation and retrieval" (p. 145). She argues that information sharing practices in academic communities, although recognized in the literature on scholars' information seeking as omnipresent, "have rarely been taken as objects of analysis in their own right" (Talja, 2002, p. 143). This might be partly due to the focus on individual information practices in existing models of information behavior (IB). IB "is conceptualized by many of these models as an intrinsically individual activity" (Reddy & Jansen, 2008, p. 257), and presented as "a linear process consisting of stages and iterative activities" (Foster, 2004, p. 228).

While some authors (Cheuk, 1998; Erdelez, 1997; Swain, 1996) have already noted non-linear movements in information practices, and have suggested the limitations of traditional linear models such as those by Ellis (1989), Kuhlthau (1993), and Wilson (1981; 1999); Foster's (2004) non-linear model of information seeking behavior was the first to be explicitly built on the concept of non-linearity. The main contributions of Foster's model to IB research are understanding information practices as non-linear, complex interactions of activities and contextual elements, and his reinterpretation of the processes of problem definition and problem solving as occurring continuously through all stages of information seeking. However, a major limitation of Foster's model is lack of clarity about how the contextual layers are linked to the

---

Correspondence to: author details provided

information core processes. The proposition here is that actor-network theory (ANT) can provide the means to capture the complexity of the links between information practices and contextual elements by shifting attention from an a priori defined existence of the connection to the action of network building.

This article first introduces Foster's non-linear model of information seeking behavior, outline its contribution to IB research, and point to its limitations. Then, in order to address these limitations, ANT and Latour's circulatory system of scientific facts are introduced. In the central part of the chapter, an alternate non-linear model of information sharing practices in academic communities is outlined. This section describes the main elements of the model and their relations to information sharing practices in academic communities. Finally, possible applications of this model and future research directions are discussed.

PROBLEM STATEMENT

Foster's (2004) non-linear model of information seeking behavior introduced a new perspective to the conceptualization of information practices; one in which "the unit of observation expands from the study of individual tasks, individual search sessions, and the study of activities in relative isolation, and becomes the study of activities within a mesh of complex interactions" (Foster, 2006, p. 165). However, this article argues that ANT provides a more effective means to capture the non-linear movements of complex social, political, cognitive, and technological negotiations involved in information sharing practices in academic communities. In this chapter, Latour's (1999) circulatory system of scientific facts is used as a foundation for building a non-linear model of information sharing practices in academic communities. The main proposition of this model is that while information sharing practices are shaped by contextual elements, they simultaneously shape the contextual elements. The main difference between this model and other IB models, including Foster's model, is this focus on the interdependence between context and information practices. Instead of a priori placing actors in a context, this model follows the actors in information sharing practices, creating themselves context. As such the model may contribute to understanding information sharing practices from the actors' point of view.

LITERATURE REVIEW

Based on a study of interdisciplinary information seeking behavior amongst researchers, Foster (2004) developed a non-linear model of information seeking behavior (Figure 1). His initial analysis of 45 in-depth, semi-structured interviews with academic and postgraduate researchers suggested that scholars' information seeking activities involved three sequential stages: initial, middle, and final. However, subsequent testing resulted in the emergence of additional underlying themes and activities that could not be explained by a stage model. This inability indicated a need for a conceptual shift from understanding information seeking as a linear process, consisting of stages, to a view of information seeking activities "described in terms of concurrent, continuous, cumulative, and looped cycles occurring throughout a research project" (Foster, 2004, p. 232). Foster classified these emergent concepts and activities into three core processes: opening, orientation, and consolidation. These three core processes are situated within three levels of contextual interaction: external context, internal context, and cognitive approach.

Core Processes

Opening ←→ Orientation

Consolidation

Cognitive Approach

Internal Context

External Context
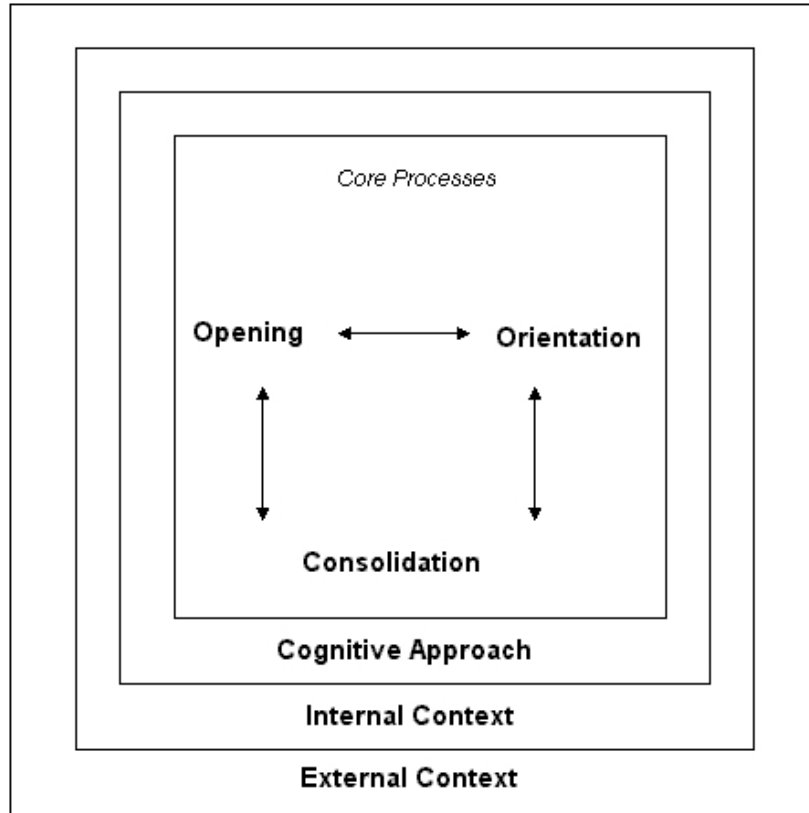
Figure 1: Non-linear model of information seeking behavior (Foster, 2004, p. 232).

Foster's non-linear model of information seeking behavior is a valuable alternative to earlier linear models such as those by Ellis (1989), Kuhlthau (1993), and Wilson (1981; 1999). While some authors (Cheuk, 1998; Erdelez, 1997; Swain, 1996) have already noted non-linear movements in information practices, and have suggested the limitations of linear models, Foster's model was the first to be explicitly built on the concept of non-linearity. Foster (2006) points out that this concept of non-linearity is used in the sciences to map relations between complex variables, and as such, it offers "a new perspective that seeks a holistic understanding of the inter-relationship of multiple individually complex variables that form information behavior" (p. 156). Information behavior changes with any contextual change and with any new information seeking experience. Information seeking activities are therefore "analogous to an information seeker holding a palette of information behavior opportunities with the whole palette available at any given moment" (Foster, 2004, p. 235).

Two main contributions of Foster's model to IB research are understanding information practices as non-linear, complex interactions of activities and contextual elements, in which any small action "may lead to a significant information-seeking outcome" (Foster, 2006, p. 160), and his reinterpretation of the processes of problem definition and problem solving. While in linear models problem definition is a stage placed at the beginning of information seeking, in Foster's model the problem definition "occurs continuously through to closure" (Foster, 2006, p. 162). Likewise, in linear models, problem solving is seen as a process of moving through successive

stages toward a solution: With each stage the level of certainty is increased until a stage of problem resolution is reached. On the other hand, in Foster's model, the certainty level is the product of a complex interaction between core processes and contextual elements, so that some activities can increase the level of certainty, and others can reduce it. The level of certainty is also determined by "previous knowledge, previous information seeking, and other contextual elements" (Foster, 2006, p. 163). Information seeking is completed when information seekers "have achieved what they consider an appropriate level of certainty for each of the problem elements for which they establish a personal threshold" (Foster, 2006, pp. 163-164).

However, Foster's model lacks clarity as to how the contextual layers are linked to the information core processes. The graphical representation of Foster's model (Figure 1) shows contextual layers as three nested squares that serve as containers for the information-seeking core processes: The movement of information practices is limited to the confines of defined contextual elements. Foster (2006) states that the core processes "are placed *within* an interactive framework of contexts, and a cognitive approach" (p. 159, our emphasis); suggesting a one-directional causal relationship from context upon information practices. This article argues that this relationship is not one-directional: While information sharing practices may be shaped by context, they also shape the context. Thus a layered presentation of contextual elements is not an adequate representation of the complex non-linear inter-relationship between context and information sharing practices. This suggests that there is a need for a different graphical representation *and* theoretical conceptualization of the context in order to capture the complexity of the links between information practices and contextual elements. The proposition is that ANT can provide the means to capture these links by shifting attention from an a priori defined existence of the connection to the action of network building, since "*the existence of this connection depends on what the actors have done or not done to establish it*" (Latour, 1999, p. 86, emphasis in original).

ANT emerged during the 1980s within the sociology of science and technology, with the work of Bruno Latour, Michael Callon and John Law. One of the main assumptions of ANT is that science is the process of heterogeneous engineering in which the social, natural and discursive are puzzled together in the process of translation. Basic concepts of ANT are actor and network. An actor is any agent, collective or individual, that can associate or disassociate with other actors. An actor is not just a point object or a placeholder (Latour, 2005, p. 153), but an association of heterogeneous elements so that each actor is also a simplified network (Law, 1992). Since the word actor is frequently used to refer exclusively to humans, the term actant "is sometimes used to include nonhumans in the definition" (Latour, 1999, p. 303). An actor or actant is "something that acts or to which activity is granted by others…[which]… can literally be anything provided it is granted to be the source of an action" (Latour, 1997). The word network came from the attempt to describe society not as two-dimensional or three-dimensional but "in terms of nodes that have as many dimensions as they have connections" (Latour, 1997). The notion of network enables ANT to replace spatial metaphors such as close/far, up/down, local/global, and inside/outside with associations and connections which are not exclusively social, natural, or technological. This is where ANT differs from most approaches to context, including Foster's, in the IB field.

According to Talja, Keso, and Pietiläinen (1999), there are two main approaches to context in the IB field. One is the objectified approach, in which context is described merely as "a background for the study of individuals' or a particular group's information behavior" (Talja, Keso, &

Pietiläinen, 1999, p. 753). The other, interpretative approach, places the context in the foreground since the context is the place where meaning is socially constructed. Hence this approach could "be called a social constructionist or discursive approach" (Talja, Keso, & Pietiläinen, 1999, p. 753). Latour (1999) would call these approaches, internalist and externalist approaches. In the first approach, content explains itself, without a need for external assistance. In the second approach, content is explained (interpreted) by society.

Latour (1999) claims that an internalist explanation without consideration of the rest of the society is "as meaningless as the idea of a system of arteries disconnected from the system of veins" (p. 80). However, this does not mean that ANT "embraces the opposite position, that of a "social construction" of reality" (Latour, 1999, p. 84). For ANT, "multiplicity is a property of things, not of humans interpreting things" (Latour, 2005, p. 116). Instead of using internalist or externalist approaches, which define a priori distance between content and context, Latour (1999) proposes an alternative model – the circulatory model of scientific facts – in which the aim of researchers is not to find a contextual explanation for a scientific discipline, but to follow "scientists themselves *placing the discipline in a context*" (p. 104, emphasis in original).

LATOUR'S CIRCULATORY SYSTEM OF SCIENTIFIC FACTS

Latour's (1999) circulatory system model (Figure 2) outlines five different activities "that all researchers will hold simultaneously if they want to be good scientists" (p. 99). Researchers have to simultaneously get their instruments to work; convince their colleagues; interest possible alliances; give the public a positive image of their work; and deal with the conceptual content of their research. These activities are represented as five interactive loops, namely: mobilization of the world; autonomization; alliances; public representation, and links and knots. If we are to understand the work of researchers, each of these loops should be described, since each "is as important as the others, and each feeds back into itself and into the other four" (Latour, 1999, p. 99). It is important to stress that ANT rejects divisions between "hard" and "soft" sciences as it rejects divisions between human and non-human actors (Latour, 2005, p. 125); therefore, this model include all actors involved in research activities within the social sciences, humanities, arts or natural sciences (Latour, 1999, pp. 18-20).
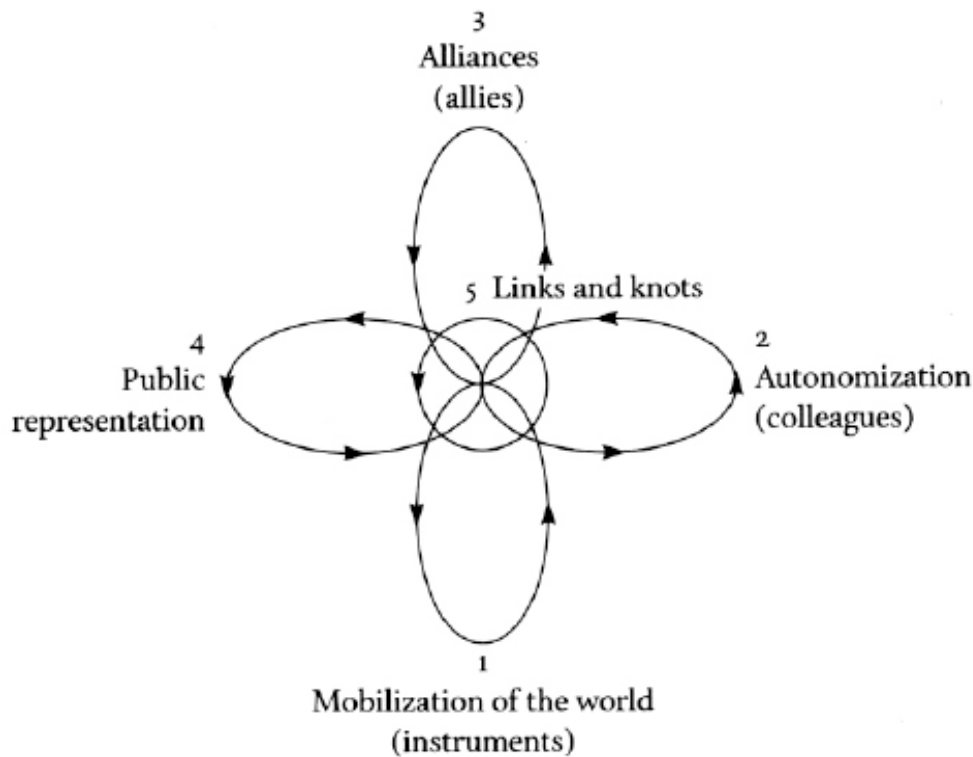
Figure 2: Latour's circulatory system of scientific facts (Latour, 1999, p. 100)

A NON-LINEAR MODEL OF INFORMATION SHARING PRACTICES IN ACADEMIC COMMUNITIES

This section outlines a non-linear model of information sharing practices in academic communities (Figure 3 below), based largely on Latour's (1999) circulatory system of scientific facts, applied to academic information sharing practices as illustration. Foster's core processes are accommodated within the central conceptual loop (links and knots in Latour's model), providing the proposed model with useful concepts of information practices described as "concurrent, continuous, cumulative, and looped cycles" (Foster, 2004, p. 232), While in the Foster model the core processes are contained within heavy layers of context; in this model, the loop of core processes is presented "more like a central knot tying the four other loops" (Latour, 1999, p. 100).

The proposed model emphasizes the interdependent relationship between contextual elements and information practices: This is the main difference between this model and other IB models, including Foster's. Context is not presented merely as a background for information practices, but at the same time, information practices are not seen simply as a construction of social or cognitive context. The proposition of this model is to follow the actors in information sharing practices, creating context and identity. Such an approach provides a more effective means to understand information sharing practices from the actors' point of view. The main elements of the model and

the relations of each loop to information sharing practices in academic communities are described below.

Mobilization of the world

The first loop in the model is called *mobilization of the world*. It refers to the "means by which nonhumans are progressively loaded into discourse" (Latour, 1999, p. 99). These means include not only instruments, equipment, expeditions, and surveys, but also the sites in which the mobilized objects are assembled and contained such as museums, libraries, databases etc. By mobilizing the world, scientists transform the world into immutable and combinable mobiles, which means that "instead of moving around the objects, scientists make the objects move around them" (Latour, 1999, p. 101). These objects, inscribed "into a sign, an archive, a document, a piece of paper, a trace" (Latour, 1999, p. 306), are mobile but they are also immutable "because the objects hold their shape as a network" (Law, 2002, p. 93).

Mobilization of the world enables things to "present themselves in a form that renders them immediately useful in the arguments that scientists have with their colleagues" (Latour, 1999, pp. 101-102). This is a major way for actors in information sharing academic communities to gain authority. Obtaining data is seen as an achievement, because data "contrary to their Latin name, are never given; they are obtained" (Latour & Hermant, 1998, p. 22). For Latour, a word does not simply refer to a thing, but it is progressively loaded with meaning through progressive chains of translations (Latour, 1999, p. 99). The study of mobilization of the world "is the study of the *logistics* that are so indispensable to the *logics* of science" (Latour, 1999, p. 102, emphasis in original). To study the logistics of information sharing practices in academic communities involves not only the study of instruments for obtaining data, but also the study of information sources and places used to keep and share these resources (libraries, databases, and information and communication technologies).

The degree of information sharing in academic communities is proportional to the speed of the circulation of all loops in the circulatory system. In an ideal situation, academics will share not only data, but also ideas, instruments, equipment, and laboratories, where appropriate. In such a situation, this loop will be a major trigger for the circulation of all other loops. In an opposite situation, there will be nothing to share, the circulation will stop, and the whole system will collapse. However, in most cases, academics do not share all of their data, selecting only certain information to be shared. Avoiding information sharing can be a result of negotiation within the *alliances* loop (discussed below) when "certain data sets funded by private commercial interests may carry usage and confidentiality restrictions that prohibit them from being shared" (Birnholtz & Bietz, 2006, p. 340). The reason may also be the researchers' attempts to gain a reputation among colleagues by being the only "spokesperson" for the mobilized objects, the only actor to have the roadmap of the chains of translations that transform these objects to information. Access to resources and instruments may be indicative of the status of researchers in the field, and consequently, circulation within autonomizationloop.

Willingness to share information therefore depends on negotiations with other actors such as colleagues, allies, and the public—the circulations of the other loops—rather than on any cognitive style, or "internal" and "external" non-negotiable forces. In order to understand the circulation of this loop, it is therefore not enough to understand the achievement of obtaining data

and building powerful instruments alone. It is also important to understand negotiations that enable the circulations of other loops through this loop. Whenever we ask how data is obtained, we have to follow with questions such as: How is this related to people's everyday activities? How will allies respond? How is it credible to colleagues?

Autonomization

The second loop is called *autonomization* since it refers to "the way in which a discipline, a profession, a clique, or an "invisible college" becomes independent and forms its own criteria of evaluation and relevance" (Latour, 1999, p. 102). This loop deals with the ways that disciplines and institutions provide credibility to the world mobilized in the first loop. Latour argues that an isolated specialist is a contradiction in terms because agreed criteria of relevance, negotiated within these associations of specialists, and regulations of scientific institutions are "necessary for the resolution of controversies as it is the regular flow of data obtained in the first loop" (Latour, 1999, p. 103). While this loop directly accelerates the circulations in the first loop by demanding more and more data, it also accelerates the circulation in other loops by increasing the credibility of data. This is why a conflict within this loop "is not a brake on the development of science, but one of its motors" (Latour, 1999, p. 102).

If for no other reason but to increase the credibility of an argument, obtained in the first loop through the mobilization of the world, researchers will participate in some information sharing activities with their colleagues. An obvious example might be the heavy reliance on peer review employed across the academy. The drive to establish credibility of information is one of the most powerful accelerators of the circulatory system. It is frequently the primary trigger for information sharing practices in academic communities, and it forms "the seeds of all relationships among researchers" (Latour, 1999, p. 103).

There are differences between academic groups that can increase the need for multidisciplinary collaboration (Katz & Martin, 1997), however these differences can also hinder or even prevent collaboration taking place (Sonnenwald, 2007, p. 653). For instance, different disciplines have different norms regarding intellectual property (Walsh & Hong, 2003), different methods and terminology that can hinder communication, and there are lower levels of trust among academics between different disciplines (Zucker et al, 1985; Shrum et al, 2001). All these issues of building relevance criteria in academic groups and institutions are directly related to the autonomizationloop. But to fully understand how this loop enables or prevents information sharing in academic communities, we have to understand how it is linked to the other loops. How do these academic communities build their laboratories, obtain their data, and use their instruments? How do they build a positive public image of their research? How do they enroll powerful allies in order to enlarge their network?

Alliances

The third loop, called *alliances*, deals with making actors outside scientific laboratories interested in the research. Without this loop, the world could not be mobilized as the instruments could not be developed, nor could a discipline become autonomous. For any research development, it is crucial to cultivate interested powerful groups and institutions, such as military, government, and industry. The links between these groups and research have to be created since there is no natural

and self-evident connection between, for example, the military and physics, industry and chemistry, or kings and cartography (Latour, 1999, p. 103). The aim is not merely to investigate the impact of research funding on research productivity, but rather to understand how different alliances create different research objects.

Alliances are never given. They have to be created, which involves "enormous labor of persuasion and liaison…to make these alliances appear, in retrospect, inevitable" (Latour, 1999, p. 104). Creating alliances is not a linear process going from basic to applied research. Howells, Nedeva and Georghiou (1998) point out in their UK survey on industry-academic collaboration that although since the 1970s the significance of linkages between industry and academic communities has become fully recognized, these linkages go back a long way, to the late nineteenth century with the establishment of so called "redbrick" universities in the industrial areas of Britain (p. 12). The aim of these universities was to serve both academic communities and aligning these communities to the local industry and economy. For example, we have seen a number of alliances built by academic communities interested in developing clean energy. Developing clean energy is becoming a major issue in winning elections in many countries.. Unlikely actors, such as car or coal industry, are building alliances with academic communities. These alliances appear more and more inevitable as academic communities translate their interests and the interests of industry into a composite goal. By shifting their interests, both industry and academic communities are not only creating a new goal but also they are building a new context. So, the context is created by actors themselves through a chain of translations. If we place *a priori* this collaboration in an external contextual element, for example capitalism, and/or in an internal contextual element, such as "anomalous state of knowledge" (Belkin, 2005), we will not be able to understand this hard work of building alliances. Instead, we should follow the actors themselves in their world-building activities.

This alliance loop is therefore not concerned solely with research funding obtained through the alignment of interests between powerful actors and academic communities. More importantly, it enables us to understand the socialization of technology. Perhaps like no other loop, it illuminates the process of swapping properties between humans and non-humans, in which social relations are transformed "through fresh and unexpected sources of action" (Latour, 1999, p. 197). However, to fully understand the impact of this socialization of non-humans on information sharing in academic communities, it is not enough to understand only the circulation between this loop and the loop of autonomization. It is also necessary to understand how it effects the mobilization of the world. How do these processes change people's everyday life? What is the public opinion of these processes?

Public Representation

The fourth loop, *public representation*, describes the effects of scientific works on people's everyday practice. Since science modifies associations between people and things, this loop is no more outside scientific work than other loops in the circulatory system, but rather "it simply has other properties" (Latour, 1999, p. 105). Public arguments for or against a research practice can have a direct impact on the funding of a particular project. For example, some governments are reluctant to fund human embryo research projects due to public concerns. This reluctance might change the dynamic of other loops, and may even stop the circulatory system as a whole. The relationship between scientists and the public has also the potential to create "a lot of the

presuppositions of scientists themselves about their objects of study" (Latour, 1999, p. 106), which may change the way they mobilize the world, enroll themselves in a discipline, or create an alliance.

The loop helps us to understand the ways society creates representations of academic work, and the ways that these representations influence information sharing in academic communities. Since academic communities need support from society, they often try to convince society of the benefits of their work through their representatives with a status of "acknowledgeable leaders" (Beaver & Rosen, 1978, p. 67). Public representation also has an impact on government allocation of public research funding and the provision of tax benefits; initiatives that encourage business and industry to enroll and invest in academic communities and their research (Autio, Hameri, & Nordberg, 1996). Public concerns about national security can also encourage governments to place restrictions on publishing and sharing "sensitive" information (Gast, 2003) impacting upon academic information sharing practices.

However, public representation is not linked only to building alliances. Public concerns can also define the object of academic activities. Finding solutions for public concerns is frequently a major motive for activities of academic communities. For example, the global threat by Severe Acute Respiratory Syndrome (SARS) motivated collaboration among scientists around the world and resulted in finding causes of the disease in only five weeks (Sonnenwald, 2007, p. 650). Thus, public representation can be both an enabler and a barrier to information sharing in academic communities. Public representation also changes with changes in a political environment. Havemann (2001) shows how information sharing between academics from East and West Germany has changed with the fall of the Berlin Wall, while Williams (1998) describes how the peace process in Northern Ireland opened the door for information exchange across the border..Jaeger and Burnett (2005) analyzed the impact of US policies on shaping information behavior in US since September 11, and found that these policies "have altered the roles of information in many social contexts, with impacts on information access and information exchange between social groups" (p. 464).

All these political, cultural, or social contextual elements, described above, circulate through the public representation loop. However, they are not enough to fully understand information sharing practices in academic communities. The public representation loop is only a part of the model. While it has a great impact on the circulation of the model, it is also an effect of the circulation. So, it is crucial to understand how this loop is connected to the other three contextual loops, and how they are all linked to and by the central loop of the model: How they are moved by, and how they are moving this loop of core processes.

Core Processes

Definition of core processes in the model we are proposing here remains the same as in Foster's model (Fig. 3). However, these processes are now explicitly connected to the contextual elements. The circulation of this loop is directly moved by the other four loops, but it also moves the circulation of all other loops. The core processes are shaped by the contextual elements, but they simultaneously shape the contextual elements, which also shape each other. No loop can circulate without circulation of all other loops. If circulation stops in only one loop, the circulation of the whole model will stop. As each loop is directly connected to each other four

loops, so each contextual element is directly connected to each activity that constitute information core processes.
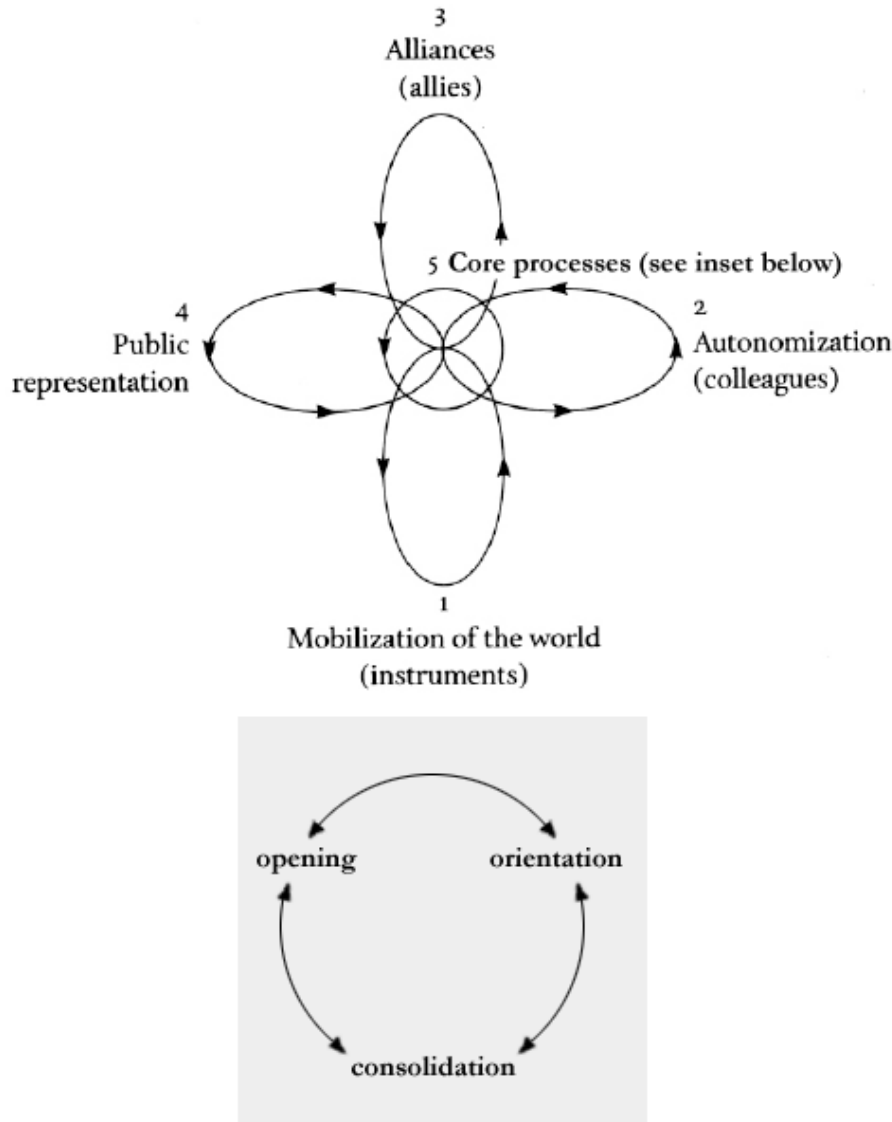
Figure 3: Proposed non-linear model of information sharing practices in academic communities

For example, an information core process, networking, which include activities that operate through channels such as "conferences, social gatherings, colleagues, and departmental research groups" (Foster, 2004, p. 233), is obviously linked to the autonomization loop. This link is so obvious that it appears to be independent from other loops. However, any change in the circulation of other loops can change the circulation between networking activities and autonomization loop. The loss of public support, or a change of instruments and/or allies, can stop this circulation, or move the core processes in a non-linear direction. Suddenly, information sharing could go back from networking to the picture building process again. From here, picture

building activities of mapping relevant concepts of research can be changed with any change in any loop. New instruments can bring new alliances. New data can change public representation. Or new public concern can create the need for new data. This is why with each contextual change, "the opportunity and need for information-seeking change too" (Foster, 2004, p. 235).

However, with each change in information practice, the contextual elements change. Any of the information core processes can change any of contextual elements. For example, any breadth exploration, a process of "a conscious expansion of searching to allow exploration of every possibility... to bring within range different information types, sources, concepts, and disciplines" (Foster, 2004, p. 233), can change circulation in the autonomization loop, which will in turn change the circulation of other loops. Or after any attempt of sifting, which is "the process of deciding which material and sources were relevant" (Foster, 2004, p. 234), there is a possibility of moving the circulation of the model from the loop of the mobilization of the world. The process of serendipity can move the circulation of the contextual elements in even more unpredictable directions. These dynamic non-linear inter-relationships between all loops, and between all loops and all core processes is the main reason for the non-linear nature of information behavior in general, particularly in information sharing practices.

While the interpretation of problem definition and problem solving is what most distinguishes Foster's model from traditional linear IB models, his definition of what or who determine the level of certainty in problem definition and problem solving activities seems to be a contradiction. While the level of certainty is defined as a product of interactions between core processes and contextual elements (Foster, 2006, p. 163); ultimately, according to Foster, individual seekers determine, according to their personal threshold, what is an appropriate level of certainty (Foster, 2006, p. 164). This contradiction is a result of a rigid presentation of contextual layers in Foster's model. As the contextual layers are presented as squares, layers, and containers, it is possible to regard them as separate entities; and consequently, to have different answer for different entities. It is possible to say that problem solving is determined by relationships between different actors, but ultimately, it is an individual seeker who has the last word. For ANT, problem definition and problem solving are the result of negotiations between different actors. They are not "generated by the state of knowledge…[but]… they result from the definition and interrelation of actors that were not previously linked to one another" (Callon, 1986, p. 228). The result of negotiation of these actors is continuous problem re-definition, which is one of the main reasons for non-linearity in information practices.

The proposed non-linear model of information sharing practices in academic communities clearly indicates interdependence between the core processes and contextual elements. This interrelation enables us to see non-linearity in information sharing processes as a result of complex negotiations, since "transfers of information never occur except through subtle and multiple transformations" (Latour, 1999, p. 298). Actors change the role from intermediaries, simply transporting information, to mediators, "actors endowed with the capacity to translate what they transport, to redefine it, redeploy it, and also to betray it" (Latour, 1993, p. 81). They change from intermediaries that are shaped by heavy layers of context to mediators that also shape the context, and "information changes from brick to clay, moved and shaped in unique ways by each perceiver" (Dervin, 1983, p. 169).

POSSIBLE APPLICATIONS

Järvelin and Wilson (2003) suggest that one of the most important principles for judging the merits of conceptual models is their ability to generate hypotheses for testing and problems for solving. Dynamic relations between the five loops, described above, constituting the non-linear model of information sharing in academic communities provide a number of possibilities for formulating hypotheses and research questions for empirical studies on information sharing such as:

- How is an orientation process, for example, problem identification, related to the translation of funding agencies' interests?
- How does access to research equipment impact upon the researchers' authority in an academic field, and how does this influence the picture building practices of other researchers?
- How is a breadth exploration process expanded or limited by a specific public concern or opinion (for example, human embryonic stem cell research)?
- What is the impact of interaction between different levels of funding in different academic fields on consolidation processes, such as knowing enough and verification?
- How does building a positive public image of research impact upon government funding?

The complexity of links between the different elements of our model enables the generation of an infinite number of research questions like those above. While the model provides a possibility to start from any loop to generate research question, it is important to remember that we have to allow circulation through all loops in order to understand information sharing practices in academic communities. For example, we can attempt to study how culture impacts on information sharing in different academic fields. In this case we would start from the public loop aiming to reach the autonomization loop through the loop of core processes. However, as this model does not allow direct access from one loop to another without circulation through all loops, we will have to investigate alliances and mobilization of the world in order to gain a comprehensive view of information practices.

CONCLUSION

The main proposition of this model is that information sharing practices and context simultaneously shape each other. This counters both objectified and interpretative approaches to context that dominate IB research. Context, in this model, is not seen merely as a background for information sharing practices, nor are information practices understood simply as a construction of internal and/or external contexts. Rather they are seen as complex negotiations between heterogeneous actors in the process of translation. Such an approach enables us to see participants in a research project not merely as intermediaries that simply transfer information, but as mediators that can act on (translate) information. It makes it possible to follow academic communities in creating their context rather than a priori placing them in a context. Therefore, this model may contribute to understanding information sharing practices in academic communities from the actors' point of view.

The model also provides potential to generate a number of research questions and hypotheses, and as such it will be a useful tool for empirical studies on information sharing in academic communities. The future theoretical improvements of the model could make it more general and expand its use as a theoretical framework for understanding information sharing in communities other than academic, and perhaps for investigating information practices in general.

REFERENCES

Autio, E., Hameri, A., & Nordberg, M. (1996). A framework of motivations for industry-big science collaboration: A case study. *Journal of Engineering and Technology Management, 13*, 301-314.

Beaver, D. D. & Rosen, R. (1978). Studies in scientific collaboration: Part I. The professional origins of scientific co-authorship. *Scientometrics*, *1* (1), 65-84.

Belkin, N. J. (2005). Anomalous State of Knowledge. In K. E. Fisher, S. Erdelez & E. F. McKechnie (Eds.), *Theories of information behavior: A researcher's guide* (pp. 44-48). Medford, NJ: Information Today.

Callon, M. (1986). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of Saint Brieuc Bay. In J. Law (ed), *Power, Action and Belief: a new Sociology of Knowledge?* (pp. 196-232). London: Routledge and Kegan Paul.

Cheuk, W. Y. (1998). An information seeking and using process model in the workplace: a constructivist approach. *Asian Libraries 7*(12), 375-390.

Dervin, B. (1983). Information as user construct: the relevance of perceived information needs to synthesis and interpretation. In S. A. Ward & L. J. Reed (Eds.), *Knowledge structure and use: Implications for synthesis and interpretation* (pp. 153-83). Philadelphia: Temple University Press.

Ellis, D. (1989). A behavioural approach to information retrieval system design. *Journal of Documentation*, *45*, 171-212.

Erdelez, S (1997). Information encountering: a conceptual framework for accidental information discovery. In P. Vakkari, R. Savolainen, and B. Dervin (Eds), *Information seeking in context:proceedings of an international conference on research in information needs, seeking and use in different contexts*, (pp. 412-421). London: Taylor Graham.

Foster, A. (2004). A non-linear model of information seeking behaviour. *Journal of the American Society for Information Science and Technology*, *55*(3), 228-37.

Foster, A. (2006). A Non-linear Perspective on Information Seeking. In A. Spink & C. Cole (Eds.), *New Directions in Human Information Behavior* (pp. 155-170). Dordrecht:: Springer.

Gast, A. P. (2003). The impact of restricting information access on science and technology. Retrieved January 24, 2009, from http://www.aau.edu/.

Havemann, F. (2001). Collaboration behavior of Berlin life science researchers in the last two decades of the twentieth century as reflected in the Science Citation Index. *Scientometrics*, *52*, 435-43.

Howells, J., Nedeva, M., & Georghiou, L. (1998). *Industry-Academic Links in the UK*. Manchester: PREST, University of Manchester.

Jaeger, P. T. & Burnett, G. (2005). Information Access and Exchange among Small Worlds in a Democratic Society: The Role of Policy in Shaping Information Behavior in the Post-9/11 United States. *The Library Quarterly*, *75*(4), 464–95.

Järvelin, K. & Wilson, T.D. (2003). On conceptual models for information seeking and retrieval research. *Information Research*, *9*(1) Retrieved March 1, 2009, from http://InformationR.net/ir/9-1/paper163.html

Katz, J. S., & Martin, B. R. (1997). What is research collaboration? *Research Policy*, *26*, 1-18.

Kuhlthau, C. (1993). A principle of uncertainty for information seeking. *Journal of Documentation*, *49*(4), 339-55.

Latour, B. (1993). *We Have Never Been Modern*. Cambridge, MA: Harvard University Press.

Latour, B. (1997). *On Actor-network theory: A few clarifications plus more than a few complications*. Retrieved July 10, 2008, from http://www.cours.fse.ulaval.ca/edc-65804/latour-clarifications.pdf.

Latour, B. (1999). *Pandora's Hope. Essays on the Reality of Science Studies*. Cambridge, MA: Harvard University Press.

Latour, B. (2005). *Reassembling the social: an introduction to actor-network-theory*. Oxford: Oxford University Press.

Latour, B. & Hermant, E. (1998). *Paris ville invisible*. Paris: La Découverte - Les empêcheurs de penser en rond.

Law, J. (1992). Notes on the Theory of the Actor-Network: Ordering, Strategy and Heterogeneity. *Systems Practice*, *5*(4), 379-93.

Law, J. (2002). Objects and Spaces. Theory, *Culture & Society*, *19*(5/6), 91–105.

Reddy, M. C., & Jansen, B. J. (2008). A model for understanding collaborative information behavior in context: A study of two healthcare teams. *Information Processing and Management: 44*(1), 256-73.

Shrum, W., Chompalov, I., & Genuth, J. (2001). Trust, conflict and performance in scientific collaborations. *Social Studies of Science*, *31*, 681-730.

Sonnenwald, D.H. (2007). Scientific collaboration: Challenges and solutions. In B. Cronin (Ed), *Annual Review of Information Science & Technology (ARIST)*, Vol 41, (pp. 643-681). Medford, NJ: Information Today.

Swain, D. E. 1996. Information Search Process Model: How Freshmen Begin Research. In *Proceedings of the 59th Annual Meeting of the American Society for Information Science*, 33, (pp. 95-9). Medford, NJ: Information Today.

Talja, S. (2002). Information sharing in academic communities: Types and levels of collaboration in information seeking and use. *New Review of Information Behavior Research*, *3*, 143-59.

Talja, S., Keso, H. & Pietiläinen, T. (1999). The production of 'context' in information seeking research: a metatheoretical view. *Information Processing and Management, 35*(6), 751-63.

Walsh, J. P., & Hong, W. (2003). Secrecy is increasing in step with competition. *Nature*, *422*, 801-2.

Williams, N. (1998). Ireland: Peace process set to boost collaboration. *Science*, *280* (5369), 1519.

Wilson, T. D. (1981). On user studies and information needs. *Journal of Documentation, 37*(1), 3-15.

Wilson, T. D. (1999). Models of Information Behaviour Research. *Journal of Documentation,, 55*(3), 249-70.

Zucker, L. G., Darby, M. R., Brewer, M. B., & Peng, Y. (1995). *Collaboration structure and information dilemmas in biotechnology: Organizational boundaries as trust production.* Retrieved January 6, 2009, from http://ssrn.com/abstract=225262