

A Nonlinear Model of Information-Seeking Behavior

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This paper offers a new, nonlinear model of information-seeking behavior, which contrasts with earlier stage models of information behavior and represents a potential cornerstone for a shift toward a new perspective for understanding user information behavior. The model is based on the findings of a study on interdisciplinary information-seeking behavior. The study followed a naturalistic inquiry approach using interviews of 45 academics. The interview results were inductively analyzed and an alternative framework for understanding information-seeking behavior was developed. This model illustrates three core processes and three levels of contextual interaction, each composed of several individual activities and attributes. These interact dynamically through time in a nonlinear manner. The behavioral patterns are analogous to an artist's palette, in which activities remain available throughout the course of information-seeking. In viewing the processes in this way, neither start nor finish points are fixed, and each process may be repeated or lead to any other until either the query or context determine that information-seeking can end. The interactivity and shifts described by the model show information-seeking to be nonlinear, dynamic, holistic, and flowing. The paper offers four main implications of the model as it applies to existing theory and models, requirements for future research, and the development of information literacy curricula. Central to these implications is the creation of a new nonlinear perspective from which user information-seeking can be interpreted.

Information-seeking behavior research has contributed to developments in information literacy and skills training, electronic resources, virtual libraries, and traditional resources. Much of our understanding derives from research, yet in some contexts, such as interdisciplinary information-seeking, the prevalence of models based on single-discipline researchers, and the assumptions that arise from them, may act to inhibit the development of further understanding and development. This paper describes research leading to a nonlinear model of interdisciplinary information-seeking

behavior with potentially wider implications for studies of information behavior.

Background

Information behavior has been the subject of many studies in the last 30 years. The highlights of research on information behavior include the highly developed behavioral model of information searching strategies by Ellis (1989), Kuhlthau's (1993) Information Search Process, and T.D. Wilson's (1997) problem-solving model. A conception of information-seeking as a process in which information needs are pursued, or in which problem-solving takes place, is found in each of these on some level. Others contributing to the rich tapestry of models, theories and perspectives include Choo, Detlor, and Turnbull (1998; 1999), Dervin (1983), Ingwersen (1996), Leckie and Pettigrew (1997), Leckie, Pettigrew, and Sylvain (1996), Marchionini (1995), and Spink (1998). Collectively these studies suggest information-seeking exists within context, and is, a linear process consisting of stages and iterative activities.

Interdisciplinarity as a context of information behavior has received a lower level of coverage in the literature and so it is included in more depth here. Mote (1962) was among the first to identify interdisciplinary topics as significantly different from single discipline topics. Mote's study revealed a higher number of inquiries for scattered as opposed to concentrated research fields. Confirming Mote's findings, Packer and Soergel (1979) re-examined the question of low- and high-scatter research problems. They recognized, but did not specify, differences in information-seeking strategies amongst interdisciplinary researchers.

The theme of differences recurs in other perspectives, such as that of information providers. Searing, while looking at library classification systems, noted that interdisciplinary material "must be squeezed into pre-existing outlays of knowledge that no longer fit the shape of current scholarly output" (1992, pp. 9–10). The problem is portrayed as the degree of fit between existing categories and the information needs of the interdisciplinary researcher. Reviews of specific subject areas are covered by Colson (1988), Mc-

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TABLE 1. Research roles and information practices, Palmer (1999, p. 248).

Research mode	Team leader	Collaborator	Generalist	Problem-oriented
Approach	Managerial	Cooperative	Individualistic	Multi-modal
Information Practices	Gathering	Finding	Probing	Gathering and probing
Knowledge Strategies	Recruiting	Consulting	Learning	Consulting and learning
Scope	Breadth	Depth	Breadth	Moderate breadth and depth
Outcome	Productive	Productive	Integrative	Productive and integrative

Dermott (1998), Stoss (1991), and P. Wilson (1996), who have provided useful insights into issues arising for interdisciplinary researchers from information organization and information overload. A study of interdisciplinarity by Bartolo and Smith (1993) used Kuhlthau's Information Search Process model as a basis for addressing the question of how search method, online or manual, affects the relevance of retrieved items, user effort, user satisfaction, user confidence and future use.

Research in the area of interdisciplinarity by Palmer (1996a, 1999, 2001) explored some of the features of interdisciplinary scientists, addressing questions related to how researchers find and use information from areas outside their core disciplines. Palmer's research considered boundary-crossing inquiries of 25 humanities scholars and 34 scientists using in-depth interviews to collect data (Palmer, 1996b, 1999; Palmer & Neumann, 2002). The research modes shown in Table 1 were related to particular research roles and practices (Palmer, 1999). Humanities scholars added strategies for extending the scope of their information-seeking and were found to be eclectic readers and active browsers who regularly probe for leads in outside domains. The information sources identified for scientists and humanists included a diverse range of informal and formal networks (especially personal networks), reliance on intermediaries, personal networks as most important, and conference attendance. Their activities included broad reading, footnote chasing, and name searching (Palmer, 1996a). More recently, Palmer and Neumann (2002) suggest that interdisciplinary humanities scholars work within a framework of Exploration, which involves Extending and Priming; and Translation, which involves Learning and Crafting.

Taking a broader view, Bates suggested that many differences between disciplinary and interdisciplinary researchers arise from three main categories: social, vocabulary and research style, and discipline-orientated support information services (Bates, 1996). The themes highlighted by Bates (1996), Searing (1992), Klein (1996), and Klein & Newell (1996) suggest a view of interdisciplinary researchers working within the context of a single-discipline information and organization context.

The picture presented by these studies suggests that interdisciplinarity is associated with the need to use a diverse range of activities and sources and in doing so perform a higher number of inquiries. Various problems arise

which some such as Palmer (1996a) and Spanner (2001) attribute mainly to its boundary-crossing nature.

No study of interdisciplinarity has achieved the clarity of the single-discipline models of information-seeking behavior of theorists such as Ellis, Kuhlthau, T.D. Wilson, and Spink. The current literature does not contain more than a partially formed image of information-seeking behavior in interdisciplinary research topics. That is to say, the core questions asked by Bates (1996) relating to possible differences between interdisciplinarity and disciplinarity, particularly behavior and strategies, remain largely unanswered. The questions raised by Bates and others suggest further questions concerning: (1) the identification of problems and strategies of information-seeking related specifically to interdisciplinarity, (2) how information needs vary, and (3) how appropriate it is to apply models based on single-discipline information-seeking to interdisciplinary behaviors. These questions lead to further questions, specifically (4) what a model of interdisciplinary information-seeking behavior would be, and (5) how this would compare with existing single-discipline models.

The research presented here aimed to answer three questions: (1) What are the activities, strategies, contexts, and behaviors used and perceived to be used by interdisciplinary information seekers? (2) What is the relationship of the core processes, contexts, and behaviors as part of interdisciplinary information behavior? (3) How can the information-seeking behavior of interdisciplinary researchers be represented in an empirically grounded, theoretical model of interdisciplinary information-seeking behavior?

Method

The study adopted methods from the tools suggested by Lincoln and Guba (1985) and Kuzel and Like (1991) for maximizing credibility, transferability, dependability and confirmability in data collection and analysis.

Data Collection

Data collection was based on in-depth semistructured interviews. An interview guide (Appendix A) described by Patton (1990) provided an agenda for open-ended questioning (see also Taylor & Bogdan, 1998). All participants were interviewed in their normal context, in this case the place of

work, as recommended by Lincoln and Guba (1985) to enhance contextual richness and minimize fragmentation. Interviews offered the opportunity to explore the experience of the participants and to elicit, by probing, new themes as they emerged. Interviewing in the work place allowed interviewees to refer frequently to bookshelves, boxes of documents, paper cuttings, Web sites and databases as concrete illustrations of normal practice. Rather than beginning with a recent specific example as a basis for the interview, the interviewer asked participants to talk in general about their behavior and allowed them to choose examples from their whole experience. These examples were then refined in member checking. Prolonged engagement was used to allow the researcher to become oriented (Lincoln & Guba, 1985) or familiar with the interviewee to reduce possibilities of misinformation and perceptual distortions. An important part of the process was presenting the interviewer as non-threatening, understanding, and nonjudgmental about the interviewee's skills and behaviors.

Lincoln and Guba's criteria of depth of data for increased credibility were supported by using an interviewer familiar, in the sense of professional experience of online searching and collaboration, with the academic disciplines involved, the use of in-depth interviews, and use of a larger number of participants than might strictly be considered necessary for a naturalistic inquiry.

Triangulation, described (Denzin, 1970; Lincoln & Guba, 1985; Patton, 1990) as adding to credibility by applying multiple sources, methods, investigators or theory to a study, was in this case included to a limited degree by inclusion of data from different faculties, for example science and arts, and academic research topics from varying from narrow to broad.

Member checking was identified by Lincoln and Guba (1985) as the single most important method of increasing the credibility of qualitative research. The present study utilized member checking in four ways. (1) Member checking at the pilot stage contributed the thoughts and opinions of a sample of five interdisciplinary researchers who were interviewed and who candidly discussed the questions following each interview. (2) Member checking took place throughout interviews as the interviewer fed ideas back to participants to refine, rephrase, and interpret. (3) Each interviewee was given the opportunity to discuss findings in an informal post-interview session. These sessions allowed comments on themes and expression of emerging patterns that contributed to the results. (4) A final member check involved gathering a sample of five participants who were willing to contribute to an additional session in which they were asked for feedback on the transcript of their own interview and evaluation of the analysis and model as a report of their own experience.

The study makes no claim for generalizability, but ultimately aims through rich description and reporting of the research process to ensure transferability and further development of the research themes (Lincoln & Guba, 1985; Patton, 1990; Sanjek, 1990). Dependability and confirm-

ability were addressed through research notes, which recorded decisions, queries, working out, and the development of results.

Sampling

The population from which the sample was drawn consisted of all academic and postgraduate researchers at the University of Sheffield, England. The population spanned the 100 research groups and departments listed as belonging to the faculties of arts and humanities, social science, engineering, and medicine. Within this body, a subpopulation of interdisciplinary researchers was chosen as a specific group from which a sample of 45 was drawn.

Nonprobability-based sampling methods were chosen as recommended for naturalistic inquiry (Henry, 1997; Lincoln & Guba, 1985; Wright, 1997). A combined method was adopted, taking account of both population and methodological context. The first stage of sampling was purposive. Purposive sampling is the selection of a sample on the basis of potential contribution as information-rich cases for in-depth study (Patton, 1990). In this study, criteria were developed to allow a rich sample with two central characteristics: identification of (1) interdisciplinary researchers and of (2) researchers representing many disciplines from across university faculties. Purposive sampling met the practical and methodological constraints of the study and maximized the potential contribution of a diverse population of interdisciplinary researchers. The sample was chosen using established criteria, not a standard from one source or a statistically confirmed standard, and was not intended to achieve theoretical saturation of coding categories. Following Patton (1990), the study combined purposive sampling with snowball sampling, which allowed the researcher to generate a larger sample by asking participants to identify interdisciplinary colleagues.

The same criteria were used for purposive and snowball sampling, beginning with a definition of interdisciplinarity. In this study, interdisciplinarity covers topics 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, relying on several subdisciplines or partial elements of disciplines (see Bartolo & Smith, 1993; Davis, 1995; Klein, 1996; Scott, 1979; and Westbrook, 1999).

The definition was supplemented by classification of potential participants based on four processes:

1. The interviewees said their topics were interdisciplinary in response to an interview question asking specifically for a definition.
2. The interviewer considered the participants' research problems and the sources they cited as providing appropriate material.
3. Following the work of Saracevic and Kzinto (1988), interviewees' problems were classified based on the sub-

ject domains listed in the DIALOG databases DIALINDEX/OneSearch categories. This approach highlights a theme mentioned by Palmer (1996a), who proposed that interdisciplinary users can only be identified by their research problem and the way that problem is defined.

4. The interviewer's own notes prevented the acceptance of merely ill defined topics or of topics that were merely subfields of a larger discipline.

These techniques resolved two potential problems with a purely discipline-based sample selection. First, disciplines that operate in an interdisciplinary fashion do not necessarily consist entirely of interdisciplinary research topics all the time. Second, academics that do some interdisciplinary research may not publicly describe or privately perceive themselves to be interdisciplinarians. Once identified, potential participants were contacted by letter, and subsequently engaged in a brief meeting, to ensure that all did indeed meet the criteria. The pilot study confirmed that the sampling methods functioned in the ways expected. The final sample consisted of 45 participants: 10 from pure, applied, and medical sciences; 14 from arts and humanities; 12 from social science; and 9 dual faculty from social science/pure science and social science/arts faculties.

Analysis

Data collection aimed at an impartial, yet theoretically sensitive, exploration of interdisciplinary information-seeking behavior. The interview guide (Appendix A) focused on exploration and allowing the emergence of concepts from participants with probes and prompts as required. Analysis was informed by knowledge of the general nature of information-seeking models rather than by specific expectations. Naturalistic inquiry analyses should be inductive and most often use the constant comparison method, as described in Glaser and Strauss (1967) and recommended by Lincoln and Guba (1985). Advice on inductive coding came from Denzin and Lincoln (1994), Miles and Huberman (1994), and Strauss and Corbin (1990). The dominant guide was Lincoln and Guba who described the coding process in terms of unitizing and categorizing.

Coding took place in multiple iterations over time. (1) Initial coding of each interview transcript began with manual annotation of scripts during a process of close reading, line by line, to highlight each concept and label it. This process equates to the unitizing or open coding process. Coding used Atlas-ti software. Subsequent iterations of reading and coding of each interview transcript in a constant comparison with previous interview transcripts and coding allowed emergence of categories and themes. Coding with Atlas-ti also allowed renaming or merging of codes as required, for convenience, but did not otherwise automate or shape the coding process. (2) Issues of consistent coding were addressed by including three iterations of coding spread through a period of a year. Each coding session considered the transcript and the application of coding in the

TABLE 2. Summary of stages and activities identified in initial analysis.

Initial	Middle	Final
Problem definition	Monitoring	Monitoring
Networking	Problem definition	Problem definition
Browsing	Networking	Networking
Breadth exploration	Browsing	Browsing
Picture building	Breadth exploration	
Identifying keywords	Picture building	Identifying keywords
Reviewing	Identifying keywords	Reviewing
Keyword searching	Keyword searching	Keyword searching
	Refining	Verifying
Chaining	Chaining	Refining

light of later analysis and the growing perceptions of the researcher and each quotation was confirmed on multiple occasions, adding to the strength of the researcher's interpretation. (3) Lincoln and Guba's method of peer debriefing was used to confirm interpretations and coding decisions including the development of categories. (4) Automatic logs of coding changes were maintained by Atlas-ti and supported by an archive of project file backups for future reference. These allowed an audit trail to be maintained, tracking the development of analysis with annotations for major decisions and researcher input. (5) Emergent code categories were tested with a specific view to dependability and confirmability. In generating themes, tests for co-occurrence of concepts using text retrieval tools within Atlas-ti allowed a large range of tests to be applied to the coding. The results of co-occurrence were checked by reading them in context and in the form of a list of quotations. Each acted to verify the analysis and highlight any inconsistencies or errors. (6) Diagrams illustrating code relationships were used to visually identify and compare patterns and inconsistency. (7) A final test of the analysis, and the most important for this study as a naturalistic inquiry, was the use of member checking, which confirmed the results as a true representation of the perceptions and experience of the participants.

Results

Broad categories relating information-seeking activities behaviors to concepts of chronological sequence within information-seeking contexts emerged early in analysis. From this approach a naïve picture of three stages, initial, middle and final was developed (Table 2). The table illustrates the behaviors initially identified with a stage model. The initial result was tested using the co-occurrence tests built into the Atlas-ti qualitative analysis software, and through visual comparison of network views of emergent codes and their relationship to one another. Evidence for the presence of stages was undermined once ideas of a passage of time and occurrence of activities were seen side by side with the resultant stages. The presence of stages was further

reduced as the existence of additional underlying themes and activities, not explained by the framework of stages, emerged.

Subsequent analysis of these additional activities, underlying themes, and behaviors in the transcripts, and a reconsideration of the activities that were initially identified with stages, suggested that these were not bound chronologically or by problem stage. The result was an extension of the number of categories and behaviors identified, as illustrated in the following section. The relationship of behaviors was described in terms of concurrent, continuous, cumulative, and looped cycles occurring throughout a research project. At a micro level, there was similarly a sense of nonsequential behavior in which any behavior could conceivably lead to any other. The combination of descriptions and coding of identified events by occurrence and co-occurrence replaced the initial notion of time. To understand this, it was necessary to move away from the level of activities and strategies to a different conceptual framework: an emergent model.

Model

Ongoing analysis of the emergent concepts and their relationship to each other developed in clusters of behaviors, intervening factors, and contexts. The concepts were grouped into three core categories, Opening, Orientation, and Consolidation around which analysis continued to develop definitions, functions, information needs, and the contexts attributable to them.

The new model of interdisciplinary information-seeking is represented in terms of three core processes and three levels of contextual interaction in Figure 1. The following sections begin with the outer layers of the illustration and

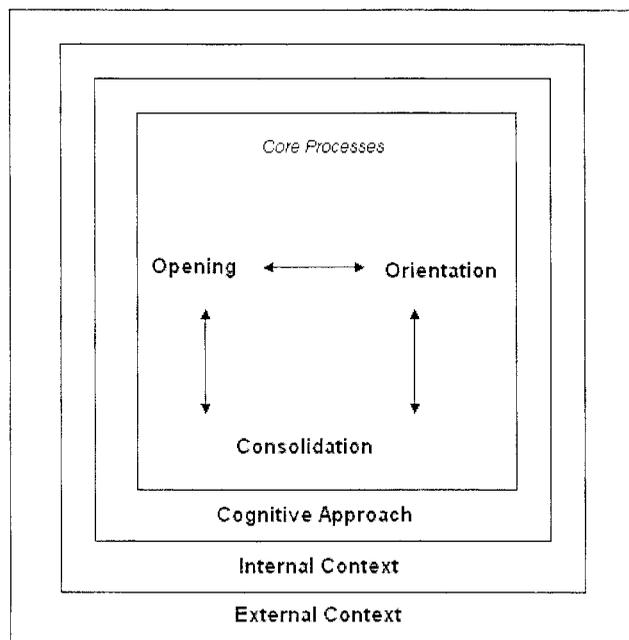


FIG. 1. Nonlinear model of information-seeking behavior.

TABLE 3. Contextual interactions of the nonlinear model.

External context	Internal context	Cognitive approach
Social and organizational	Feelings and thoughts	Flexible and adaptable
Time	Coherence	Openness
The project	Knowledge and understanding	Nomadic thought
Navigation issues		Holistic
Access to sources		

move towards the core processes of Opening, Orientation, and Consolidation, culminating in a summary of the whole model. The final list of contextual interactions appears in Table 3, and a list of the core processes appears in Table 4.

External Context

Information behavior is not isolated from the context within which the information seeker works. Major external influences were categorized as Social and Organizational, Time, The Project, Navigation Issues, and Access to Sources. The social networking aspect of interdisciplinary experience was one of the most significant. Social networking was identified in Opening as a source that could have the effect of either reducing access to information resources or significantly bolstering them. Socially, interdisciplinary information-seeking was dependent upon goodwill networks between individuals from a variety of backgrounds, status and disciplinary origins collaborating to share information. The surrounding organizational climate also affected funding and access to resources such as interdisciplinary journals. A difference between a positive encouraging atmosphere and a negative restrictive culture was noticeable.

Information-seeking was found to be framed by the resolution of information problems, which for interdisciplinary researchers may be open ended, and by limits to time and financial resources, coded as Time and The Project.

Navigation Issues and Access to Sources referred specifically to the organization of information, and to the problems incurred by interdisciplinary researchers as they move from the familiar territory of their home discipline towards the alien information environment of other disciplines. The

TABLE 4. Core processes of the nonlinear model.

Opening	Orientation	Consolidation
Breadth exploration	Problem definition	Knowing enough
Eclecticism	Picture building	Refining
Networking	Reviewing	Sifting
Keyword searching	Identify keywords	Incorporation
Browsing	Identifying the shape of existing research	Verifying
Monitoring		Finishing
Chaining		
Serendipity		

impact appeared to vary with associated factors such as distance from home discipline and previous experience, identified as part of Internal Context.

Internal Context

Internal influences are primarily the level of experience and prior knowledge held by the information seeker. Major influences were categorized as Feelings and Thoughts, Coherence, and Knowledge and Understanding. Each represents complex concepts within the analysis, including internal feelings of uncertainty, self-perception, self-efficacy, perception of topic, complexity, and distraction. Knowledge and Understanding covers experience, information need, and knowledge level. Internal influences are factors unique to each information seeker's own profile.

Cognitive Approach

Cognitive Approach describes aspects of the mode of thinking observed in the participants, a willingness to identify and use information that might be relevant to an interdisciplinary problem. The interdisciplinary researchers who took part in the study described four Cognitive Approaches.

1. The Flexible and Adaptable approach emphasizes the mental agility and willingness to adapt to the different information and disciplinary cultures that are intrinsic to working in an interdisciplinary field.
2. Openness of approach is an open-minded approach in which no prior framework for judging relevance is implemented: all sources, disciplines and ideas are viewed as viable until proven otherwise. The concept suggests that interdisciplinary researchers use flexibility and adaptability in their information-seeking and when they find a potential information source are open to how this might fit in with their information needs.
3. Nomadic Thought appeared at first to be the same behavior as Openness. It does, however, go further in that it embraces the process of thinking about a topic in many diverse ways to find the information needed in locations and ways remote from the original idea. Key elements include the idea of abandoning well-known and favored disciplines and sources in search of new material. This tends to contradict the traditional idea of staying within known disciplines and well-trodden resources.
4. The Holistic approach was highlighted in the earliest interviews as important to grasping and incorporating concepts from diverse areas and bringing them together either as an answer or to generate new questions and information searching directions.

Opening

The concept of Opening may bring to mind the starting, initial moves or initializing operations found in some other models as the first step in information-seeking behavior (Ellis, 1989; Kuhlthau, 1993). That is, models of information behavior have all tended to describe starting points.

Starting points in these models entail a number of activities or processes such as problem definition, initial searching, and exploring, and are often seen to exist at the beginning of a search.

Opening was identified as corresponding with the process of moving from a state of orientation to actually seeking, exploring and revealing information. Interviewees suggested during the member checking process that the term "opening" best described how they opened up their topics through information-seeking activities. Opening is a non-linear component representing a collection of activities. Each of the activities interacted and informed both further Opening activities and the other core processes. Two activities, Breadth Exploration and Eclecticism, were identified as complex in that they involved combinations of other activities to form a larger process, though these worked alongside other activities. The key element was the combination and recombination of possibilities to achieve information.

Breadth Exploration was identified as a conscious expansion of searching to allow exploration of every possibility. This included deliberate expansion of information horizons to bring within range different information types, sources, concepts, and disciplines. Interviewees described it as a "kind of splatter gun approach" which was associated particularly with starting wider so that narrowing could produce results. Implications of this activity for the Orientation process were identified as choice of keywords, selection of sources, and the initiation of combinations of other core processes.

Eclecticism encompassed accepting, gathering and storing information from a diverse range of both passive and active sources, sometimes over considerable time periods, for later incorporation and satisfaction of information needs. Eclecticism influenced information-seeking as a determination to obtain information from as many channels as possible and to absorb as many pieces of information as possible to reveal new concepts and ideas. Eclecticism provides a conceptual approach to finding information that combines active, passive, and serendipitous information acquisition.

Networking appeared as a main activity of participants and operated through many channels, including conferences, social gatherings, colleagues, and departmental research groups. The Internet, E-mail, and Mailbase groups were valued for increasing the possibilities for Networking, and hence locating information and sources. Networking was recognized by participants as a tool for exploring interdisciplinary subjects and opening up new concepts and areas not revealed through traditional searching. Much of the decision to use Networking was placed in the context of limited knowledge, limited resources such as time and access, and coping with information overload.

Keyword Searching during Opening was associated with use of databases, online catalogues, Internet search engines, and online journals. Results from Keyword Searching were viewed as valuable but sometimes ineffective when terminology was not always appropriate or transferable across

disciplines. Browsing was found to be a key process for accessing information, of most use to information seekers who needed to change their disciplinary focus.

Monitoring via repeat visits to obtain updates has a similar meaning to that used by Ellis (1989), and was highlighted in the data as part of the ongoing processes following identification of fruit-bearing sources of information. In Monitoring, ease of access played a significant role, with reliance on Internet Web sites and particularly homepages of useful people or organizations, Mailbase lists, current periodical shelves and new book catalogues.

The activity of Chaining, identified by Ellis (1989), was found to be strong in the researchers' behavior pattern. In the present study, citation and reference chaining were joined by an emphasis on the chaining of important ideas from one source to another. The activity led researchers from single leads in known areas towards a broader information horizon.

Serendipity, identified as a method for achieving breadth and identifying unknown results, was found to be closely associated with Browsing, Eclecticism, and Networking. Serendipity and activities that encouraged the occurrence of serendipitous results were frequently mentioned as a valued part of information-seeking.

Orientation

Orientation processes, or as one interview suggested, "finding which way was up," encompass a diverse range of activities covering the identification of existing research, key themes, disciplinary communities, latest opinion, sources, keywords, and picture building. Orientation focuses on identification and which direction to look. The activities and strategies found in the Opening process feed results into the Orientation process, but Opening can also lead back into further Orientation or Consolidation in a dynamic interplay.

A primary component of Orientation was identified as Problem Definition, in the classic sense of defining the focus and boundaries of the information problem. It was noteworthy that the process was not clear cut; participants said they repeatedly redefined problems up to closure of information-seeking.

Picture Building was a composite set of behaviors that participants described as mapping out in their minds, and on paper, the disciplines and concepts relevant to achieving an interdisciplinary overview of the topic.

Reviewing was identified as the use of existing knowledge in an area, reading or accessing a personal collection and considering material already gathered. Determining "where I am now" through Reviewing established a baseline of information from which ideas of "identifying which gaps need filling next" and "developing those seeds of information" followed.

Identifying Keywords was finding suitable terms for subsequent searching. Identifying the Shape of Existing Research involved the processes of Identifying Key Names,

Identifying Key Articles and Identifying Latest Opinion in Disciplines. Identifying and Selecting Sources required using relevance criteria to decide which sources were appropriate. Identifying Disciplinary Communities was deciding on the basis of information, past experience, topic, or general knowledge of which disciplines might be appropriate places to look for information.

Consolidation

Consolidating was found to be less likely as a first move in information-seeking for many information seekers, although Consolidation plays a part in every interaction from an initial idea for a topic or information product. A key theme of Consolidation is that of judging and integrating the work in progress and deciding whether further information-seeking is necessary. In the context of interdisciplinary research, Consolidation looped and intertwined with Orientation and Opening.

A main concept of Consolidation was termed Knowing Enough, which emerged as a reiterative process of questioning of whether sufficient material to meet the present information need had been acquired. This was closely connected with Refining, which appeared as the process of deciding on boundaries for searches and of selecting a narrower search focus. As information was collected and sources highlighted, Sifting, the process of deciding which material and sources were relevant, took place. This was a recurrent process of selecting and pruning. The concepts of judging relevance and of relevance criteria were important properties of Sifting. Incorporation was identified as a key information organization process. Interviewees found it necessary to pause in their diverse information-seeking to assemble the material they had been exposed. The process of incorporation took place as a combination of thinking, writing, and discussing with colleagues. Incorporation was recurrent throughout information-seeking. Verifying was a less common aspect of interdisciplinary information behavior. Some interviewees reported feeling uncertain of their ability to judge the accuracy of material from other disciplines, but a feeling of information overload prevented their doing additional searching to verify the contents of papers. Where it did occur, Verifying tended to be limited to the accuracy of quotations and references. Interviewees described one other process identified as Finishing, composed of activities as diverse as Browsing, Keyword Searching and Networking. This process was described by one participant as "sweeping up the loose ends" before closure.

Summary

The Nonlinear Model of Information-Seeking illustrates the process of information-seeking in a way that reflects the experience of information seekers. The core processes of Opening, Orientation, or Consolidation take account of the interaction between the information seeker and his/her Cognitive Approach, and their Internal and External Contexts.

With each information-seeking experience, or contextual change, the opportunity and need for information-seeking change too. The relationship of core processes and developing context interact freely to allow each core process to feed into any other and to be reiterative over time.

The names given to the core processes almost suggest a sequence of activity. However, the concepts, represented in the interactivity of the core processes, and the absence of stages in the model, are analogous to an information seeker holding a palette of information behavior opportunities, with the whole palette available at any given moment. The interactivity and shifts described by the model show information-seeking to be nonlinear, dynamic, holistic, and flowing.

Conclusion

The study sought answers to three questions: (1) What are the activities, strategies, contexts, and behaviors used and perceived to be used by interdisciplinary information seekers? (2) What is the relationship of the core processes, contexts, and behaviors as part of interdisciplinary information behavior? (3) How can the information-seeking behavior of interdisciplinary researchers be represented in an empirically grounded, theoretical model of interdisciplinary information-seeking behavior?

The first research question was answered through the identification of behaviors and strategies present in the description of the Nonlinear Model of Information-Seeking Behavior. These behaviors extend previous research and point to the value of considering both internal context and external context alongside individual activities to enable a holist portrait of information-seeking behavior. The behaviors identified emphasize the variety of approaches in use, while also indicating that these are flexible and only fully understandable within a view of changing contexts.

The second and third research questions were fully addressed by development of the model. The model considers new aspects of interdisciplinarity and tackles the concept in greater depth than previous studies. Activities and behaviors have some crossover with existing models, although the relationship of activities in this holistic context highlights different aspects of importance. While the use of naturalistic inquiry has proven valuable in refreshing our understanding of a complex phenomenon, further research is planned to fully develop generalizability and will need to combine qualitative and quantitative methods.

The model offers a complex multilayered tool to explain and further explore interdisciplinary information behavior. It goes further to suggest a possible foundation for the exploration of general information-seeking behavior. Four major implications arise from the new model.

1. An alternative to sequential stages is offered as a means of understanding information-seeking. The data suggested that a problem-solving framework, as adopted in many existing models (e.g., Kuhlthau, 1993; Wilson,

1997), was not present. Instead, the results explicitly point to problem definition and, more widely, information-seeking behavior to be cumulative, reiterative, holistic, and context-bound. The model represents one slice of a temporal continuum within which a palette of nonlinear behaviors exists.

2. The advent of a new model offers an alternative explanatory framework for user information-seeking behavior that represents a shift between earlier linear models and the beginnings of a new generation of studies. The new model addresses anomalous patterns of behavior and missed stages noted in the application of previous models. Its existence immediately suggests a need to reconsider some key concepts in further research.
3. The use of models of information-seeking to set the agenda for teaching information skills has been a crucial element in library and information studies curriculum design over many years. The direct practical implication of the model points to revising the teaching of information literacy and library skills. The new model offers the basis of a framework for educators and library professionals to teach both academic and non-academic, and expert and non-expert information users in a manner that reflects actual behaviors and real-world solutions rather than the artificial conceptualization of stages. Work in progress is tentatively applying the new model in curriculum design at the undergraduate level, and investigating application of the model to different teaching contexts.
4. The model's approach to understanding information-seeking behavior within a context is credible and of interest to a wide audience. Initial examination of additional data suggests that the model's core processes are echoed at the level of individual search episodes. This suggests different and successive layers of activity within the same model. Each layer maintains the overall picture, much like the composition of a fractal. Future studies will need to address the highly focused question of search episodes to develop this aspect of the model.

To conclude, this paper offers a new, nonlinear model of information-seeking behavior, which contrasts with earlier models of information-seeking behavior. It offers a potential guide for a reinterpretation of information-seeking behavior as a dynamic flowing holistic process and points to many lines of future investigation and development.

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Appendix A: Interview Guide

1. Please define what you understand by the word “interdisciplinary.” (Seek clarification of this definition if necessary.)
2. Have you previously worked in a mono-disciplinary area? (What was the area? / For how long?)
3. How do you approach the task of researching on a new area? (How focused are your thoughts? / How do you define your topic in the beginning? / How do you draw together ideas?)

4. How would you characterize the approach you take to solving the information problem?
5. Describe for me the things that you do to find information. (Probe at each step for what you do/need/feel/think, where you look.)
6. Please think of an overview of an entire project from a title or area through to completion: Please tell me about the activities and places that you look as you progress through a project. (Probes: At the beginning. / Once you are a little further into the area what would you do? / A little later in your research perhaps when you have done some searching or worked for a while on the topic. / As your work progresses and towards completion of your research?)
7. Do you feel that there is a difference in what you were looking for, and what activities you do, at the beginning and as you move through?
8. Do you change what you do to find information, or perhaps put different emphasis on activities or sources at different points in a project? (If you use the same strategies and activities, can you describe them for me? / If you use different strategies and activities, can you describe them for me? / How do the activities you describe fit in with your overall strategy of information-seeking?)
9. When you change from one topic to another do you change the things you do to find information? (In what ways?)
10. Does what you do to find information change as you move from between different types of topic? (In what ways?)
11. When you are looking at interdisciplinary topics: a) What information do you need to find? / b) What do you look for? (If there is a difference in either of these questions, why is there a difference? [Asked only if there is one.]
12. Where would you look for information? (e.g., Information sources types e.g., Database, Library Shelves, Web)
13. How do you identify new or useful information sources? (When looking at a range of sources, how do you decide which ones will be worth using? / When looking at the results of a search, how do you decide which results are relevant?)
14. What differences do you think there are between working on a mono-discipline topic and working on a topic that might cover two or more disciplinary areas? (Thinking about how you find out about an interdisciplinary area, in the ways you have described: is that the same, or is it different from, single discipline topics? / If it is different, why do you think that is?)
15. Do you find some strategies or activities work more effectively, or indeed less effectively, in research for interdisciplinary topics? (Why do you think that is so?)
16. What tends to move you on to using a new strategy or activity to find information?
17. When are you satisfied that you have enough information and can therefore move on to a new question, activity, or different way of searching?
18. Please describe for me any problems or issues raised by interdisciplinary topics. [Examples generated from previous interviews]: perhaps in identifying content, access to information sources, identifying resources, judging relevance) / Have you had any difficulties in locating information for this topic? (Why do you think that is?)
19. What would you recommend to someone starting a similar topic to improve his or her chances of finding relevant information?
20. How would you perceive your process of information-seeking: Is it as clearly defined stages or as many smaller parts or something else?
21. Age, Professional Status, Academic Background, Disciplines.