Information for Inspiration: Understanding Architects' Information Seeking and Use Behaviors to Inform Design

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Architectural design projects are heavily reliant on electronic information seeking. However, there have been few studies on how architects look for and use information on the Web. We examined the electronic information behavior of 9 postgraduate architectural design and urban design students. We observed them undertake a self-chosen, naturalistic information task related to one of their design projects and found that although the architectural students performed many similar interactive information behaviors to academics and practitioners in other disciplines, they also performed behaviors reflective of the nature of their domain. The included exploring and encountering information (in addition to searching and browsing for it) and visualizing/appropriating information. The observations also highlighted the importance of information use behaviors (such as editing and recording) and communication behaviors (such as sharing and distributing) as well as the importance of multimedia materials, particularly images, for architectural design projects. A key overarching theme was that inspiration was found to be both an important driver for and potential outcome of information work in the architecture domain, suggesting the need to design electronic information tools for architects that encourage and foster creativity. We make suggestions for the design of such tools based on our findings.

Introduction

Information is of great importance when planning, designing and reviewing the construction of buildings or other structures. Indeed, Shaaban et al. (2001) highlight that "information is a critical element for architects to accomplish their tasks" (p. 43), with the architect's role being "to manipulate this information to reproduce it in a meaningful form, which are often described as designs" (p. 43). Despite the importance of information for architectural design, there has been relatively little research on how architects look for, interpret, and use information in the context of their design projects. There has been even less research aimed at supporting architects in conducting their information-related activities (whether by informing the design of electronic tools to support this work or through the design and delivery of information-related training).

As a step towards addressing these gaps in research, we conducted naturalistic observations of nine postgraduate architectural design and urban design master of architecture (MArch) students—observing the students undertake a self-chosen, naturalistic information task that was related to one of their current or recent design projects. The aim of these observations was to gain a detailed understanding of the information behavior displayed by the architectural students, encompassing how they not only find information but also interpret and use this information as part of their design projects. Our aim was then to feed this understanding into suggestions for the design of new or improvement of existing electronic information tools to support (or better support) their information work (i.e., their information-seeking and use practices and behavior). We also fed our findings back to the students' university architecture librarians, who used them to develop a one-to-one information support program for the students.

In this article, we review what little published work there is on architects' information needs and behavior, paying particular attention to work that has informed the design of library services and electronic information tools. We then provide a theoretical context for our work by discussing the behavioral approach to identifying information behavior, drawing on studies in various disciplines conducted by David Ellis, his colleagues and subsequent researchers. We also briefly discuss research on creativity and information

Received December 14, 2009; revised February 16, 2010; accepted February 16, 2010

 • Published online 19 July 2010 in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/asi.21338

behavior (as architectural design projects are inherently creative in nature). Next, we detail our methodology and present our theoretical and practical findings, discussing these findings in light of the literature. Finally, we conclude by making suggestions for the design and improvement of electronic information tools for architects based on these findings.

Background: Architects' Information Needs and Behavior

Despite the importance of information for architects, particularly when undertaking design projects, there are surprisingly few published studies of their information needs and behavior. The work that does exist tends to focus on gaining a detailed understanding of practicing and academic architects' information activities. Although this provides a valuable insight into architects' information work in the context of real architectural design situations, it is less valuable for making suggestions for the design and/or improvement of electronic information tools (or indeed library services) to support this work. Implications for design are considered in information-related studies in other design disciplines (for example, see Choguill's 1992 study of constructing and housing professionals' information needs, Court's 1997 study on the relation between information, knowledge, and memory for engineering designers, and Mougenot et al's 2008 study on car designers' information use). However, very little previous work uses an understanding of *architects*' information work to inform the design of electronic information tools aimed at supporting this work or to inform the development of library services. As space restrictions prevent a detailed review of information-related studies in several design disciplines, we focus our review on the few studies that have examined architects' information needs and behavior or have led to the design of electronic information tools or library services for architects (albeit without explicit empirical feed-in). Although many of these studies were carried out recently, others were conducted in the 1970s and 1980s when information seeking was almost entirely paper-based. Although this makes comparing findings across studies difficult, value can still be gained from the insights these studies provide on the *nature* of architectural information work, which we do not believe has changed much over time.

Goodey and Matthew (1971) surveyed and interviewed architects' offices across the United Kingdom to find out, among other things, how information was handled and fit into broader work practices within the offices. Only 57% of the offices regarded research literature as a main source of information. Although this study was conducted several decades ago, several participants in our study suggested that when undertaking design projects, architects rely less on research sources such as journals and more on practical ones, such as design-focused books or Web sites. Regarding information flow and context, Goodey and Matthew found that when information arrived by post, it was generally passed to the most senior member of the firm, who would decide what to retain and inform staff of its arrival. They found that often literature was not catalogued until it had been passed round the office for inspection, leading to "a pile-up of badly needed technical literature on designs and in private collections" (p. 13). These private collections, although not always encouraged, were found to be extensively used across offices. The authors comment that "it looks as though each architect has a favourite set of references which are used over and over again" (p. 18). Mackinder (1983) suggests that these private collections make it quick for architects to refind information. She suggests that aside from independently published sources, architects often collect trade publications. According to Mackider's practical experience as an architect, these are favoured because they are comprehensive and well-illustrated. She suggests that the ideal information for architects is "brief and visual," asserting that architects "show a remarkable lack of enthusiasm for the written word" (p. 103).

Snow (1975) reports findings from a telephone enquiry service (and follow-up interviews and questionnaires) aimed at discovering architects' "wants and needs for information.' She found that most information required was for immediate problems, where quick solutions were required and usually consisted of product or technical information. However, she found that information was also required to solve complex design problems, where the complex technical information provided can be considered "a method of keeping up to date and learning about new techniques" (p. 116). She concluded that "information retrieval should be viewed as an essential part of the decision-making process, i.e., the design/build process in architecture" (p. 121) and suggested the need to integrate information work into the student curriculum. Although the architectural students in our study were introduced to paper-based and electronic library services during their course and routinely looked for information as part of their studies, information seeking had not been made an integral part of their curriculum.

Powell and Nichols (1982) interviewed architects and engineers to understand their information needs and how they access, interpret, and use this information in the context of their everyday design work. They found that very few research documents "present new information or ideas in a form that is readily exploitable by the designer" (p. 309) and, therefore, the architects only sought information when a design problem was deemed to be both new and significant. Otherwise, they dealt with the design problem based on past experience. Like Goodey and Matthew, the authors found extensive use of personal information collections, with 95% of interviewees keeping "a limited selection of product data, secure, at hand by their drawing boards" (p. 310).

A rare example of observing architects' work practices, including some information practices, to inform design is demonstrated by Elliott (2002). Elliott enrolled in a post-professional design studio course and conducted an ethnography as a participant-observer. She supplemented this work with interviews and firm visits. Elliott's firm visits highlighted the importance of sketching, collage making, and

DOI: 10.1002/asi

image browsing among the architects. She found that architects made collages in the early stages of design to understand the relationship between parts of a form and the materials they have chosen to work with and to learn about how structures can be put together. Additionally, she found that sketching and image browsing were tightly coupled activities for architects and suggests that "one [electronic] environment should allow architects to do both" (p. 194). Elliott also found that looking at images (e.g., site plans, aerial photographs, existing or historical buildings/maps) was "a key part of starting a design project" (p. 174) and that sharing images with colleagues was important, particularly in the early phases of design. However, she found that none of the four architects interviewed used the Web to acquire these images. Some of the reasons given were that it was too time-consuming, too difficult to know where to look, and too difficult to find things even when the architects know they are there.

Elliott sought to address these shortcomings in Web image search support by making design suggestions to support common image-related information tasks (which she drafted "based on previous research from other domains," p. 179). The first of these tasks was monitoring (keeping aware of current developments in the field), "such as advances in the use of titanium as an external finish, or new buildings by a prominent architect" (p. 178) by looking at images. The second task was retrieving known images. The third was gathering background information about a project "by looking at examples of other buildings of the same type and other buildings from the same area" (p. 178). The final task involved getting inspired by using images "to provoke an outburst of creativity, possibly to generate a new plan or to solve a stubborn problem" (p. 178). Elliott found that this inspiration often came from nonarchitectural sources and from personal collections of favourite images. Elliott then used these tasks as the theoretical basis for designing the Flamenco Image Browser, described in Elliott (2001). This image search tool "dynamically generates query previews to give the user hints about where to go next" (p. 70) and allows users to specify some images of interest and search for "more like this." The tool sorts image results into four different groups based on aspects of the image metadata (e.g., architect, geographical location, type of building, materials used to build) and users can browse further images from these groups.

Elliott (2002) suggests that "architects' information retrieval needs aren't substantially different from general information retrieval needs" (p. 178) and that "emerging information retrieval research can be directly applied to architectural tasks." We only support this view to a limited extent, as while architects might perform some similar information behavior as other types of professionals, the research literature (and our findings discussed later in this article) highlight many unique aspects of architects' information behavior that have not been found, or have been found to be less important, in other disciplines.

Bennett (2006), an academic art and architecture librarian, asserts that studio art and architecture students are two particularly difficult groups to attract to the library. She argues that these students do not perceive library research as relevant to their design projects or coursework, "and as a result do not recognise their own valid and extremely challenging research needs" (p. 38). Bennett suggests that these students are particularly interested in "items fostering original observation through accidental discovery" (p. 38). In her article, Bennett describes several methods she tried to "lure" these students into the library. One of which was a focus group, where students explained that they regarded their research as more "spontaneous" than traditional research and suggested that the library was particularly valuable for its image collections. When asked how they prepared for a project about which they knew very little, one student's response was "I try Google or ask my professor or friends" (p. 39). Bennett concludes that information seeking among these students might be encouraged by relating "traditional library services" to the students' design projects.

Finally, George et al. (2006) conducted semistructured interviews with graduate students from all disciplines at Carnegie Mellon University to find out about aspects of their information-seeking behavior. They found that, apart from humanities students, art and architecture students reported the least use of the Internet in general, of online journals and of Google, to search for both Web sites and academic articles. These findings are supported by a survey by Rhodes (1998), who found that studio designers (including architects as well as interior and product designers) did not use the Internet regularly because it either failed to provide the "right kind of information" or provided "just too much information." Instead, the studio designers expressed a preference towards magazines and journals and having conversations with colleagues.

The reviewed studies provide an interesting insight into the nature of architects' information activities and begin to demonstrate the potential of using an understanding of this work to make information work easier for architects—whether by feeding into the development of library services as with Bennett (2006) or the development of electronic information tools as with Elliott (2002). Indeed, this is also our motivation for the study of architects' information behavior and related design suggestions described in this article. We now discuss the theoretical context for this study by examining previous work aimed at understanding information behavior to inform design.

Background: The Behavioral Approach to Informing Design

Between 1989 and 1997, David Ellis and his colleagues conducted a series of interviews with academic and practicing researchers from a variety of scientific disciplines that resulted in the derivation of the highly cited "behavioral model of information seeking" (Ellis, 1989). Ellis's behavioral model has been subsequently refined by various researchers (Meho & Tibbo, 2003; Makri, 2009), validated in other nonscientific domains (Makri 2009), validated in

DOI: 10.1002/asi

commercial (as opposed to academic) environments (Ellis, 1993; Makri, 2009), and validated through naturalistic observations in addition to interviews (Makri, 2009). This model was developed with the purpose of informing the design of electronic information resources and has been used to make design suggestions for how electronic resources can support or better support behaviors (see Ellis, 1989; Makri et al., 2008) and as the basis of two user-centred methods for evaluating the functionality and usability of electronic information resources (see Makri et al. 2008).

Allen (1996) highlights that "it is important for library and information science to establish a link between research and design" (p. 45) and suggests the importance of a user-centred approach for the design of information retrieval systems. We argue that the behavioral approach, and Ellis's model in particular, provides a useful bridge between information science theory and user-centred design. In Makri et al. (2008), we suggested that the behavioral model was particularly useful for informing the design of electronic information tools primarily because of the level of abstraction at which behavior is modelled. We argued that the model minimizes the creative leap required when designing to support observed behavior, allowing systems developers to ask the question "how can we design to support or improve support for this behavior?" and to make design suggestions without having to drill down much further to ascertain what a particular behavior entails at the interface level. This argument was supported (albeit anecdotally) through the successful use of the model by a group of electronic resources developers to structure functionality evaluations of their own prototype and a competitor's electronic resource (see Makri, 2009).

Ellis's Behavioral Model and Subsequent Refinements

Ellis's model comprises a number of information-seeking behaviors, identified from semistructured interviews with social scientists (Ellis, 1989), physical scientists (Ellis et al., 1993), engineers and research scientists (Ellis & Haugan, 1997), and English literature academics (Ellis, 1993). These behaviors are nonsequential and potentially overlapping (i.e., it is possible to display more than one behavior at any given time and, more specifically, to facilitate one behavior through performing another).

Since 1997, a number of further studies have refined Ellis's model, usually (although not exclusively) by identifying different or additional behaviors. In particular, Meho and Tibbo (2003) revisited Ellis's study of social scientists and found that although, for the most part, their information behavior had not changed much since Ellis's original study, the social scientists also performed some information use and communication-related behaviors (alongside the information-*seeking* behaviors identified by Ellis and his colleagues). Similarly in a study of academic and practicing lawyers, Makri (2009) identified a number of information use behaviors, as well as some behaviors that were specific to the nature of the legal domain. Finally, as part of a synthesis of the information behavior literature across several disciplines, Palmer et al. (2009) discuss these behaviors alongside other behaviors identified in the literature. Although many of the studies described by Palmer et al. did not employ a behavioral approach to identifying information behavior, they are discussed under behavior-style headings and can be constituted as behaviors in their own right.

The behaviors identified/discussed by the abovementioned researchers, albeit with some minor differences in terminology used, include:

- *Starting/surveying*. Starting involves "activities characteristic of the initial search for information" (Ellis et al., 1993, p. 359), while surveying elaborates on this definition and is defined as "characteristic of the initial search for information to obtain an overview of the literature within a new subject field, or to locate key people operating in this field" (Ellis & Haugan 1997, p. 395).
- *Chaining*. "Following chains of citations or other forms of referential connections between material" (Ellis, 1989, p. 179). Ellis (1989) highlights that there are two types of chaining: forwards chaining (which involves identifying and accessing documents which have subsequently cited the current document) and backwards chaining (which involves following references to documents that have been cited in the current document).
- *Browsing*. "Semi-directed searching in an area of potential interest" (Ellis, 1989, p. 179).
- *Differentiating/distinguishing*. "An activity which uses differences between sources as a filter on the nature and quality of the material examined" (Ellis et al., 1993, p. 179). Ellis (1989) explains that "differentiating is effected by the researcher identifying different sets of sources in terms of the differing probability of their containing useful material" (p. 190).
- *Filtering*. The "use of certain criteria or mechanisms when searching for information to make the information as relevant and as precise as possible" (Ellis & Haugan 1997, p. 399). Filtering is commonly undertaken when narrowing down search results (for example, by telling an Internet search engine to only display pages in English or from a particular country).
- *Monitoring*. "Maintaining awareness of developments and technologies in a field through regularly following particular sources" (Ellis & Haugan, 1997, p. 396).
- *Extracting*. "Systematically working though a particular source to identify material of interest" (Ellis et al., 1993, p. 364). Most commonly, extracting involves reading all or selected parts of a document (e.g., title, headings) to identify useful information.
- *Verifying*. "Checking the information and sources found for accuracy and errors" (Ellis et al., 1993, p. 364). Ellis and Haugan (1997) suggest that verifying behavior was not identified in Ellis's earlier study of social scientists, as it seemed only to be an important behavior in its own right for physical/research scientists and engineers. Meho and Tibbo (2003) did, however, identify verifying behavior among the social scientists they interviewed.
- *Ending*. "The assembly and dissemination of information or the drawing together of material for publication" (Ellis et al., 1993, p. 365).

DOI: 10.1002/asi

A number of additional behaviors were later identified by Meho and Tibbo (2003); these were as follows:

- *Accessing*. "Getting hold of the materials or sources of information identified and located" (adapted from Meho & Tibbo 2003, p. 581).
- *Networking*. "Characterized by activities associated with communicating, and maintaining a close relationship with a broad range of people" (p. 582).
- *Information managing*. "Filing, archiving, and organizing information collected or used in facilitating their research" (p. 582).
- *Analysing and synthesizing*. These behaviors were identified but not greatly elaborated on by Meho and Tibbo. Adopting definitions based on adaptations from the Oxford English Dictionary, analysing involves "examining in detail the elements or structure of the content found during information seeking" and synthesizing involves "combining these elements into a coherent whole."

Further additional behaviors were then identified by Makri (2009); these were as follows:

- *Searching*. "Formulating, submitting, editing and filtering queries" (adapted from Makri, 2009, p. 115). Searching was not discussed by Ellis and his colleagues (perhaps because of the paper-based nature of information seeking in these studies) and discussed only briefly by Meho and Tibbo (2003).
- *Selecting*. "Carefully choosing as being potentially useful" (adapted from Makri, 2009, p. 145). When looking for electronic information, selecting is usually associated with deciding whether to click on a particular link or search result. Although "distinguishing" between these links or results might involve ranking them based on perceived importance before choosing to click on one or more of them, selecting is more of a binary choice—"Should I click on this link/result or not?" Both "selecting" and "distinguishing" usually involve some "extracting" too, because it is almost always necessary to identify material of interest to justify examining a document in more detail. For example, when looking through a search results list, consider reading a snippet of text that includes the search terms used in the context of the document to decide whether or not to click on a particular result. In this example, "extracting" behavior is performed to support "selecting."
- *Collating and editing*. Collating involves "drawing together for later use" and editing involves "preparing and arranging for later use by making revisions or adaptations" (adapted from Makri 2009, p. 183, 185). Although Meho & Tibbo mention "synthesizing" behavior in the context of writing a final product (Meho & Tibbo, 2003, p. 585), "collating" can be regarded as a physical (rather than cognitive) activity to support future assimilation; when collating information, it is grouped together or packaged for later use (for example by saving several documents as a single file or batch printing them to review them together later). Therefore, collating can be regarded as an optional precursor to "analysing" the information found further and "synthesizing" it into a new written document. It can also be regarded as distinct from "information managing" and "gathering and organizing" behaviors (discussed later), as it does not involve organizing the information beyond the rudimentary batching of documents of interest.
- *Recording*. "Making a record" (adapted from Makri, 2009, p. 166). This might be a record of information resources or sources used, documents or content found, query terms used, or results returned in a search, etc. "Collating" often works hand-in-hand with "recording" behavior, because a saved or printed record is usually kept of collated documents.
- *Distributing*. "Handing or sharing out to others" (adapted from Makri, 2009, p. 185). Although Ellis"s definition of "ending" encompasses "dissemination," typical ending activities described by Ellis and his colleagues involved conceptual gap filling by searching for final pieces of information (rather than the physical act of disseminating that information).
- *Updating and history tracking*. These behaviors, which are particularly pertinent to information seeking in the legal domain, involve "ensuring a current understanding of amendments or changes to a particular document" and ensuring a historical (as opposed to a current) understanding of changes, respectively (Makri, 2009, pp. 172, 178). The emphasis of these behaviors is on understanding the importance of a particular legal document such as a case or piece of legislation rather than understanding a new topical area (as with Ellis's "starting/surveying" behaviors). Certain "monitoring" activities (such as setting up e-mail alerts related to a particular legal document) can, however, support updating and history tracking (e.g., new developments in a particular legal area highlighted in an e-mail alert might trigger lawyers to challenge their existing understanding of related cases or pieces of legislation). Although Ellis and Haugan's "verifying" involves checking a document for accuracy and errors, updating and history tracking involve ensuring an accurate understanding of the current or historical importance of a document, rather than looking for errors or omissions in the textual content itself.

Finally, Palmer et al. (2009) discuss other behaviors identified from the information behavior literature:

- *Probing*. "An exploratory strategy used by interdisciplinary researchers to find relevant information that falls outside their discipline or area of expertise" (p. 14). This is similar to Ellis's "starting/surveying" behaviors, as it often involves gaining an overview of a topical area. However, while starting and surveying are performed when looking for information on any new topical area (even within the current discipline of study), probing involves looking for information in an unfamiliar discipline.
- *Gathering and organizing*. Setting up and maintaining a personal collection of information. Organizing involves "devizing organizational systems and tools for storing and managing the content" (p. 18). These behaviors are related to Meho and Tibbo's "information managing" behavior, which may involve storing and organizing information found (but does not necessarily involve maintaining a personal collection). These behaviors are also related to Makri's "recording" behavior, because maintaining a personal collection of information can be regarded as a specific example of keeping a record of information.
- *Coordinating and consulting*. Coordinating group work and "contacting colleagues and other experts for assistance"

DOI: 10.1002/asi

(p. 28), respectively. These two behaviors, along with "networking" (which is discussed by both Meho and Tibbo, 2003 and Palmer et al., 2009) are strongly interlinked. For example, consulting can be regarded as a means of utilizing relationships that have been established through networking and networking can lead to collaboration, which may involve coordinating group work.

- *Notetaking*. "The "scribbling" and "jotting" of ideas and other informal writing" (p. 30). Palmer et al. highlight that "discussions of writing practices have often focused on scholarly publishing, with little attention to how writing contributes throughout the scholarly production process" (p. 30). Although comments and annotations may be made when "editing" textual content (see Makri, 2009), Palmer et al.'s "notetaking" can occur at various times during information seeking and use.
- *Translating*. "Navigating the literature and research practices of another field by developing familiarity with new terminology, concepts, theories, and methods" (p. 31). Although this behavior is similar to "starting" and "probing," the emphasis is on understanding the research conventions of an unfamiliar discipline rather than gaining an overview of a particular topical area.

Palmer et al. (2009) also discuss a number of reading behaviors, such as *scanning* (which can be regarded as a type of "extracting" aimed at quickly identifying material of interest in a document), *rereading* (which can potentially aid more useful "extracting"), and *assessing* (which involves "assessing for relevance and utility," p. 20, and can, therefore, be regarded as a combination of "selecting," "distinguishing," and "extracting" behaviors). A number of writing behaviors are also discussed by Palmer et al., such as *assembling*—"composing thoughts through writing" (p. 22), which is similar to Meho and Tibbo's "synthesizing,"—and *coauthoring*, which is a form of collaboration that can come about through "networking."

For each of the above-mentioned information behaviors, it is possible for systems designers to consider ways of supporting or better supporting the behavior. For example, consider integrating the facility for electronic notetaking within an electronic information resource or improving support for forwards chaining in an electronic information resource by automatically listing documents that have cited the current document at the time the document or citations are viewed (rather than by asking the user to click on a "subsequently cited" or similarly named tab).

Many of the above-mentioned information behaviors are performed not only when undertaking unique, complex information tasks but also during routine, simple tasks. It, therefore, follows that these, alternative or additional behaviors are likely to be performed when undertaking information-seeking and use activities related to architectural design projects, which often require the architect to be "creative." Indeed, it can be argued that creativity is an inherent aspect of the nature of architectural work. Hence, we conclude our literature review by discussing Schneiderman's (2001) creative framework that can be used to describe information work.

Background: Creativity and Information Behavior

Architectural design projects often require creativity for design outcomes and information-seeking and use activities. According to Durling (1997), "designers are noted for ideation or divergent thinking" and "[their] creativity is also linked strongly to intuition" (p. 8). Durling explains that "whereas science students proceed step-by-step to analyse a problem and seek to understand underlying principles, designers tend to 'play' with a problem until a solution is found" (p. 8). Architects "play" with design problems throughout the design process and, most pertinent to this article, at all stages of information seeking, interpretation, and use. They often seek a creative, as opposed to routine, solution to fit their design brief—perhaps one of the reasons why architecture is considered to be not only a practice but also an art.

Given that creativity is an important part of architects' information work, we now examine the creativity framework by Schneiderman (2001) that can be used to describe information activities. Schneiderman's "Genex" framework describes four creative activities and potential associated information tasks. He points out that the activities are nonlinear but related, suggesting that "creative work may require you to return to earlier phases and much iteration" (p. 214). The four activities are as follows:

- *Collect*. Learning from previous works storied in libraries, on the Web and in other places. Potential information tasks include searching and browsing electronic resources, visualizing data and processes to understand, and discovering relationships.
- *Relate*. Consulting with peers and mentors for intellectual and emotional support.
- *Create*. Exploring, composing, and evaluating potential solutions. Potential information tasks include thinking by free association to make new combinations of ideas, exploring solutions, composing artefacts and performances, and reviewing and replaying session histories to support reflection.
- *Donate*. Disseminating results and contributing to libraries, the Web, and other places to gain recognition and add to the searchable resources.

Schneiderman argues for the integration of multiple creativity support tools to support the collect-relate-create-donate process, suggesting that "the main challenge for users and designers is to ensure smooth integration across these novel tools and with existing tools such as word processors, presentation graphics, e-mail, databases, spreadsheets and Web browsers" (p. 217). This framework can be considered useful for considering not only architects' information activities as a component of the broader creative design process but also creativity as a potential driver for and outcome of both information seeking and the design process itself. We relate our findings to Schneiderman's framework later in this article.

Lee et al. (2005a, 2005b) also present a framework that describes several stages of "creative information seeking." However, we do not discuss this framework in detail, as

DOI: 10.1002/asi

while Schneiderman describes a set of "creative activities" that information seeking might be undertaken to accomplish (which could potentially result in imaginative design solutions for architects), Lee et al. describe creativity as a *property* of information seeking, suggesting the need for an imaginative approach to information tasks, particularly when these tasks are complex and nonroutine. Although this might also lead to imaginative design solutions as a byproduct, Lee et al.'s framework essentially describes a different type of creativity, *information process creativity*, while Schneiderman's framework primarily describes *the creative process* itself.

Methodology

This study was conducted with the aim of understanding architects' information-seeking and use behaviors. In particular, we were motivated by a broad research question: Which electronic information-seeking and use behaviors are particularly pertinent to architects when working on design projects? By focusing on this question, we hoped to identify information behaviors that were highly related to architectural design projects rather than those commonly observed across disciplines (which are usually associated with traditional scholarly information tasks, such as writing academic papers). Our study adhered to the core principles of Glaser and Strauss's (1967) grounded theory methodology. This included adopting a cyclic approach to data gathering and analysis, which involved "listening to the data" rather than seeking to accept or reject a particular hypothesis. When following such an approach, new and more highly focused research questions often emerge as a deeper understanding of the phenomena under investigation (in this case architects' information behavior) is gained. Two additional research questions emerged from our findings: (a) what is the importance of images and video for architectural design projects? and (b) how does the creative nature of architectural design projects influence architects' information-seeking and use behaviors? We discuss our findings in relation to both of these emergent themes later in this article.

We conducted a naturalistic observation of nine postgraduate students who were studying in the faculty of the built environment at a large London university, which comprised three architectural design and six urban design masters of architecture (MArch) students, aged 20–25 years. We decided to observe postgraduate students because, unlike undergraduate students or academic staff, the students were all working on their own personal architectural design projects at the time of our study. These projects, chosen in consultation with an academic tutor from a list of various realistic design briefs, were highly design-focused and did not involve much traditional scholarly research. However, the research component of the projects did involve the use of both paper-based and electronic information resources.

For the architectural design students, all of the projects involved the detailed design of a building and were based on one of two briefs. One of the briefs involved designing a building that interacts somehow with its surrounding environment. One student chose to *"design a building which is responsive to the environment, probably by taking vibrations out of the bridges and roads and these vibrations can feed my building"* (P2). Another student (P6) tackled the same brief by researching the "boundaries of human motion" to come up with an idea for a "responsive" building. Student P1 also tackled this brief. The other architectural design brief involved selecting a site in a part of London in need of regeneration and proposing a regeneration plan. Two students, P5 and P8, chose this brief. The urban design students were also given one of two broad briefs: the first was to create an "urban fiction," a futuristic vision in the form of a short film of what London or Paris might look like in a hundred years' time. This brief was chosen by P4 and P7. The second brief was to plan for how London could ensure economic sustainability in the future. One student (P3) envisaged that population increases might lead to greater reliance on food imports and, therefore, the need for "urban agriculture." He, therefore, decided to look into ways that existing buildings could be used to grow food, to make the city more self-sufficient. Another student (P9) researched how the introduction of new types of industrial setups might lead to economic sustainability. All of the project briefs shared similar characteristics: they were broad in nature and could be approached in a number of different (and creative) ways; they required a significant amount of research to complete; they required students to look for a mix of textual, image-based and possibly video-based information; and they required this information to be assimilated and turned into a unique (and hopefully creative) design proposal.

We hypothesized that observing information tasks related to students' design projects would provide a useful insight into architects' interactive information behavior in the context of realistic architectural work. In contrast, we did not believe that observing scholarly information activities would be as successful in highlighting aspects of information seeking and use that are unique to architectural work. We recruited the participants through an e-mail sent through the departmental administrator and through word-of-mouth. The only specified prerequisite for participation was that electronic research should be an important part of their design project. We do not believe the self-selection of participants had a negative impact on our findings.

As conducting our naturalistic observations in the design studio itself would have been disruptive, we decided to conduct them in a small computer room on campus. The observations involved first asking the MArch students to think of an information task to undertake. The students were told that this should be a real task that requires the assistance of electronic resources and that this task may be based around one of their design projects. The students were also told that if they do not currently need to perform an information task, then they could step through a recently completed task but they do not need to undertake it in exactly the same way as they did previously. It was emphasized that their main aim should be to perform their chosen information task in as natural a manner as possible.

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The MArch students were asked to think aloud when undertaking their chosen information task (i.e., to verbalize their interface actions, thoughts, and feelings) and were shown an example of how to do this. During the observation, the students were asked probing, opportunistic questions about what they were doing and why and how the interactive information behavior they were demonstrating fit in with their design project. These questions served several purposes. One purpose was to encourage participants to verbalize aspects of their interactions that might not otherwise have been verbalized (e.g., their reasons for clicking on a particular search engine result); an example question in this category was "Why did you do x?" Another was to elicit further or more concrete details (for when participants stopped demonstrating concrete behavior and started talking about their information behavior in the abstract). Example questions in this category were "What did you just do?" and "How exactly did you do x?" Another purpose was to elicit reasons for behavior demonstrated, to test our assumptions, and check our understanding. Example questions included "Why did you do x?" and "Did you do x for y purpose?" A final purpose was to probe the boundaries of the interactive behaviors identified, to find out how these behaviors contribute to the broader design project, and to highlight information behavior that is important for architectural design projects, but not currently supported by existing electronic information resources (i.e., behavior that it might be important for electronic resources to support in future). Example questions in this category included "Do you ever do anything similar to this, such as x?" and "What did you do/are you likely to do next, now that you have done x?" We had previously found this methodology to be useful when observing the interactive information behavior of human-computer interaction and library and information science students (see Makri et al., 2007) and both academic and practicing lawyers (see Makri et al., 2008 and Makri, 2009).

Informed consent was obtained and the think-aloud data was anonymized at the time of transcription (which involved removing mentions of individual and institution names). The think-aloud data was analyzed, using a thematic coding approach, following many core principles of Glaser and Strauss's (1967) grounded theory methodology such as constant comparison and theoretical sampling and saturation. However, we stopped short of generating a full theory, as we were interested in observing a range of interactive behavior rather than in generating a theory by identifying a "core" behavior. We regard our overarching theme of "information for inspiration" to be important for describing the students' information behavior, but not a central part of their information work (and, therefore, not a "core" category in the grounded theory sense). Our coding process was deductive in the sense that information behaviors were allowed to "emerge" from the data rather than attempting to "force fit" them to existing models. However, we also used the information science literature as data, constantly comparing our findings to various existing information-seeking models. This was with the aim of highlighting aspects of behavior that had not been previously modelled rather than simply highlighting similarities between our findings and findings from previous studies.

Findings were triangulated through semistructured interviews with two architecture subject librarians working for the university library. In the interviews, the behaviors and overarching themes identified were discussed and the librarians' comments (and, in particular, their reflections on our findings) sought. Our findings were used by the librarians as the basis for informing a new program of one-to-one search support for MArch students, where students were invited to book an appointment with one of the subject librarians, who would show them electronic resources and relevant search skills tailored to their particular design projects. This can be considered an example of relating library services to students' design projects, as called for by Bennett (2006). In the next section, we discuss our findings, making reference to excerpts from the observations with MArch students (numbered P1 to P9) and to our interviews with the architecture subject librarians (L1 and L2). In these excerpts, "R" denotes a researcher question, while [. . .] denotes that some text has been omitted to make the excerpts more concise.

Overview of Architecture Students' Electronic Resource Use and Information Behavior

The MArch students were in the early-to-mid planning stages of their research, having received only their project briefs a few weeks earlier. This may well have influenced their information behavior. In particular, we believe this may have led to the demonstration of more unfocused, "exploratory" behaviors than might have otherwise been noted if the students were at a later stage of their design project (such as finalizing the design choices made). Indeed, Vakkari (2003) highlights that the nature of an information task can influence the interface-level activities performed by users. Similarly, Markkula and Sormunen (2006) found that when observing television journalists at the early stages of making a program (i.e., when generating ideas and planning), the journalists' information requirements were general and vague. They became more specific after a focus for the program had been identified. Although two of the MArch students had rather vague information needs (such as to look into "how to capture human motion" and "how to measure vibrations in buildings"), the remaining seven students had developed a specific focus for their project. For these students, exploratory information seeking was also important, not for providing a focus, but for generating more ideas to flesh out the project.

When performing their self-chosen information tasks, the MArch students made almost no use of dedicated electronic architectural resources such as the Royal Institute of British Architects (RIBA) digital library, despite many resources being listed by subject on the university library catalogue. Instead, they almost always used the Internet search engine Google to find information. One architectural

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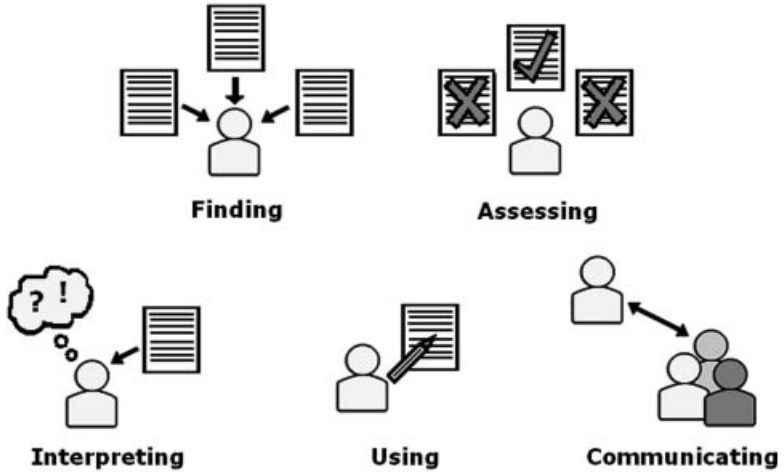

FIG. 1. The five high-level information behaviors we identified.

design student explained that she did so to stay within her "comfort zone":

> R: Do you use any electronic databases, for example, to look for diagrams or articles?
>
> P4: No electronic databases actually. Somehow I find them a little confusing, so I don't go to them. Google mostly gives everything. So it's easy! It's like life! Once or twice I think I went to the library site and I knew I could use it to get the information. But it's more about not wanting to go outside of your comfort zone. If I don't get something in Google, then I do sit in the library as well, look through books.

Architecture subject librarian L1 recalled approaching a confused MArch student in the library, who was looking for information on her design project. The student got embarrassed when the librarian asked her whether she was primarily using Google for her research and became perplexed when the librarian asked whether she was aware of any architecture-specific resources. Indeed, there was low awareness of dedicated architectural resources among the MArch students, with a typical response to the question "Have you used any other electronic resources for your project, such as electronic architectural databases?" being "What sort of electronic databases do you mean?" (P6). In addition to lack of awareness, another reason for the lack of use of dedicated resources was the (nonacademic) nature of the design projects that the students' information tasks related to, as one urban design student explained:

> R: Do you ever use any electronic libraries?
>
> P9: I use JSTOR that way, but that's usually when I'm looking for academic articles related to a specific thing. For example, I had to write an essay on Modernism and then I went to JSTOR and looked for specific articles on Modernism and Modern Architecture.
>
> R: So, it's more for academic articles?
>
> P9: Yeah, academic articles.

Indeed, the design-focused nature of information work in the architecture domain suggests that the use of dedicated resources is not as important for architects, as explained by subject librarian L2:

> L2: So, the fact that there aren't dedicated image databases specifically for architects in the same way as there are bibliographic databases we would view as a problem, but they do not necessarily see it as a problem because of how they use the information.

The students also searched for a variety of different types of "digital objects" (i.e., images and video as well as mostly text-based documents), emphasizing the importance of visual media such as images and videos for architects. The general level of search sophistication displayed by the students was, however, low. Although all the students were able to explain what information they were looking for clearly and succinctly verbally, they had much more difficulty translating their information needs into effective search queries. Markkula and Sormunen (2000) also noted a similar finding when observing photojournalists searching for images. Like the MArch students in our study, the journalists "did not pay much attention to selecting search keys or formulating a query." (pp. 274–275).

Despite these search difficulties, the MArch students displayed a wide variety of lower level information behaviors that can be placed under the five high-level headings of *finding*, *assessing*, *interpreting*, *using,* and *communicating* information (see Figure 1). In the next section, we discuss the lower level behaviors found to be particularly important for architects.

Detailed Findings and Discussion of Architecture Students' Information Behavior

The MArch students displayed a broad range of information behavior that encompassed not only finding and

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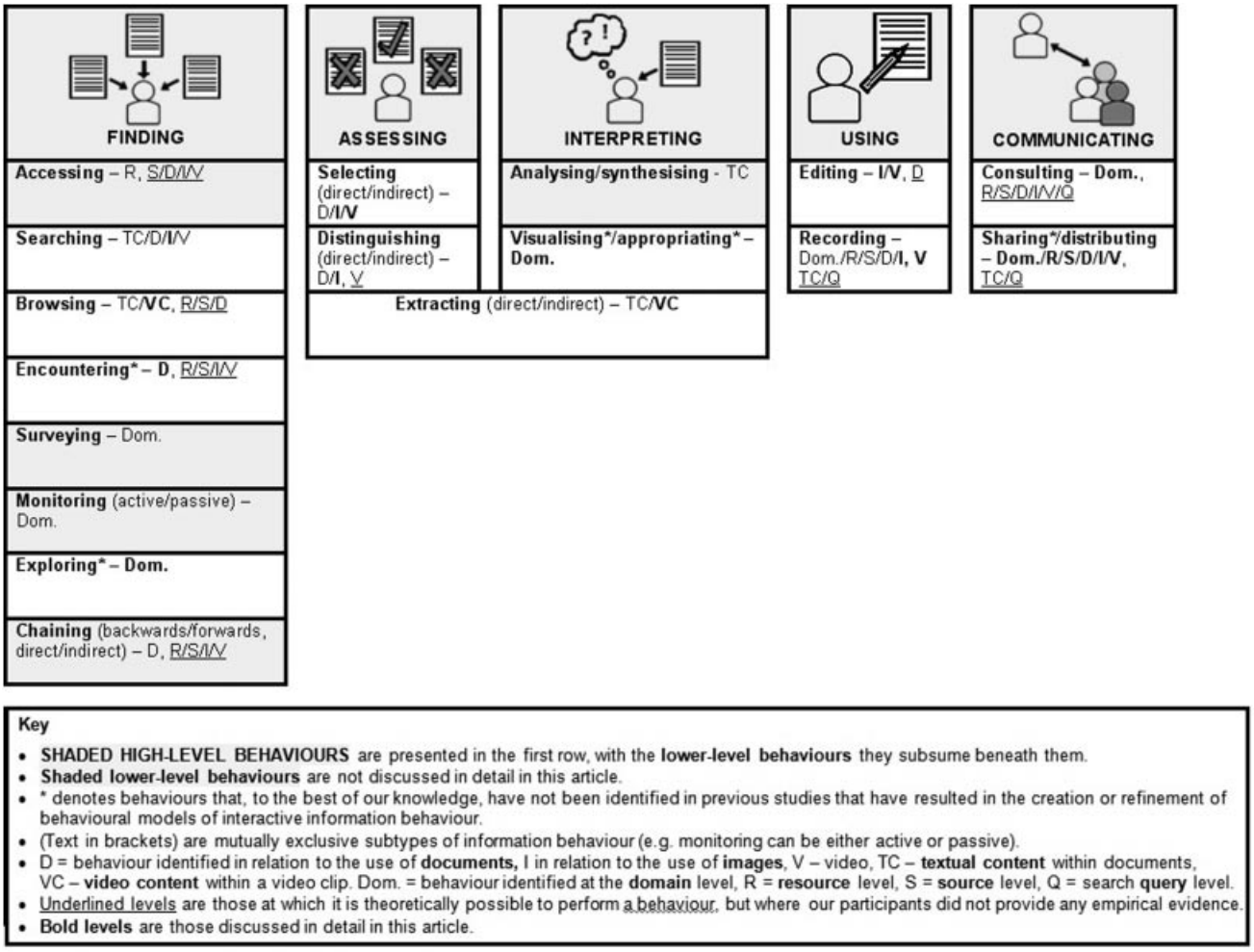

FIG. 2. Lower-level information behaviors related to the five high-level behaviors we identified.

assessing information but also interpreting it, making use of it as part of their design projects and communicating it to others (as well as communicating with others to aid information seeking). The behaviors related to finding information were accessing, searching, browsing, encountering, surveying, monitoring, exploring, and chaining. Behaviors related to assessing information were selecting, distinguishing, and extracting. Behaviors related to interpreting information were analysing/synthesizing and visualizing/appropriating. Behaviors related to using information were editing and recording. Finally, the behaviors related to communicating information were consulting and sharing/distributing. These behaviors are presented in Figure 2. Definitions of each of these behaviors are provided alongside our findings. Many of these definitions have been adapted from those already presented as part of our literature review. As can be noted from our literature review, information use and communication behaviors have rarely been identified in previous studies (perhaps because many of these studies focused solely on information seeking). We suggest that information use and communication are particularly important for architectural design situations, where the information found must feed in to a design solution which, in turn, must be communicated to others (in the MArch students' case, this was their tutors and peers, but in a commercial design setting, this is likely to be a client).

We identified several lower level behaviors that have been discussed in the broader information-seeking literature but, to the best of our knowledge, have not been featured in previous behavioral models of information behavior (such as those presented by Ellis, 1989; Meho & Tibbo, 2003; Makri, 2009). These were encountering, exploring, visualizing/appropriating, and sharing and are denoted by an asterisk in Figure 2. We suggest that although these behaviors might also be identified in other domains, they are particularly pertinent to the nature of architectural design.

As with our study of lawyers described in Makri et al. (2008), we also identified a number of levels at which many of the behaviors could operate. These leveles are as follows: *topical domain*, resource, source, document, *textual content*, *image, video, video content*, and search query. As an example

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of how a particular behavior might be performed at various levels, consider the "recording" behavior. It is possible to "make a record" of a particular electronic information *resource* such as a Web site/digital library (or a particular information *source* within it, such as an individual Webpage or a particular electronic journal) by bookmarking it. It is also possible to make a record of *documents*, *images*, or *videos* by bookmarking or downloading them and of search *queries* by bookmarking the search results or maintaining a search history. We define electronic "documents" as "textual or mixed-media electronic matter that provides information" (definition adapted from Oxford English Dictionary). This includes both material with a relatively structured format, such as journal articles and less structured material, such as individual Web pages and blogs. The terms "image" and "video" are based on standard Oxford English Dictionary definitions.

As an example of behaviors at each of the other levels, it is possible to extract both *textual and video content* for later use by looking through it and gain an overview of (survey), monitor developments in, or explore a particular *topical domain* by conducting a range of searches in the area. Note that although some documents contain only textual content, the textual content level described above also encompasses mixed-media content (such as Web pages that contain both text and images). We decided to use the label "textual" content as, usually, documents on the Web (including Web pages) contain mostly text (and we wanted to disambiguate this level from the video content level, which refers to content that is entirely video-based).

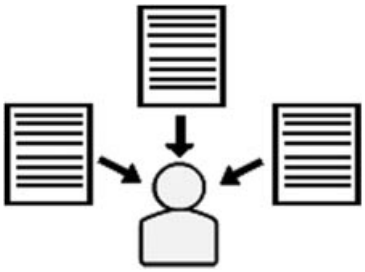
The levels presented in italics in the previous paragraph serve to further refine Ellis's model (and serve to update our previous refinement of Ellis's model described in Makri et al., 2008 and Makri, 2009). This refined model takes into account that people may find and use not only documents (containing either textual or multimedia content) but also other digital objects such as images and video. This refinement was driven by the fact that we found that the MArch students in our study made extensive use of images and video. The refined model also takes into account that some behaviors (surveying, monitoring, exploring, and visualizing/appropriating) are best described at the topical domain level. For example, although "surveying" behavior might involve viewing documents, images, or video (and the textual or video content within them), the purpose is to gain an overview of a *topical area* rather than a particular digital object. The same can be said for the other behaviors (although it is theoretically possible to consult others about particular digital objects or search queries used as well as a topical domain, which is why multiple levels are listed for "consulting"). This refinement serves to add further clarity to our previous refinement of Ellis's model.

The levels at which we found each lower level behavior to operate in our study of MArch students are listed in abbreviated form in Figure 2 next to the relevant behavior. Next to the identified levels for each behavior are additional levels at which we believe it is theoretically possible to perform the behavior (but where no empirical evidence was found in our study). For example, "accessing" behavior was identified at the resource level, but we also believe it is possible to access individual sources, documents, images, and video within a resource. This is abbreviated as "R, S/D/I/V" in Figure 2. Many of the lower level behaviors identified among MArch students were found to operate at some of these additional levels in our study of lawyers (Makri, 2009).

Like in our previous study of lawyers' information behavior, we also identified several mutually exclusive behavioral subtypes (presented in parentheses in Figure 2). For example, each individual instance of monitoring behavior (maintaining awareness of developments) can be either active (facilitated by pull technologies such as conducting regular searches) or passive (facilitated by push technologies, such as e-mail alerts), and chaining (following chains of citations or other forms of referential connections) can be performed in either a backwards or forwards direction and can be achieved either directly (for example, by following a hyperlink) or indirectly (by performing more involved interface actions, such as manually searching for a citation). Selecting and distinguishing can also be performed either directly (by choosing or ranking digital objects by looking at the objects themselves) or indirectly (by choosing or ranking objects based on metadata). Extracting can also be performed directly (for example, by reading the textual content of a document or watching a video clip to "identify material of interest") or indirectly (for example, by skipping to particular parts of a video or document text).

We now discuss the ways in which the MArch students performed each of the lower level behaviors and levels that were found to be particularly important for architects (i.e., the nonshaded behaviors in Figure 2). Behaviors deemed to be important were those particularly pertinent to information seeking and use in the architectural domain and rarely noted in other disciplines. This includes behaviors such as encountering, exploring, visualizing/appropriating, and sharing. An asterisk in Figure 2 denotes these newly identified, lower level behaviors. The remaining unshaded lower level behaviors in Figure 2 have frequently been noted in other disciplines. However, they have rarely been discussed at the *image*, *video,* and *video content* levels in other behavior-focused studies. For example, previous studies have focused on how people browse within *textual content* as opposed to video content and select/distinguish between documents as opposed to images or video. In this article, we focus our discussion on how the MArch students performed these commonly identified behaviors at each of these *newly identified* levels. That said, it is important to note that the architects did perform *all* of the unshaded behaviors in Figure 2, at each of the nonunderlined levels. However, we discuss only the unshaded behaviors in Figure 2 and only at the levels listed in bold next to them. We frame our discussion using the high-level behaviors of finding, assessing, interpreting, using, and communicating as section headings. We also discuss how our findings relate to previous work.

DOI: 10.1002/asi



Finding

The MArch students displayed many lower level behaviors related to finding information (whether actively, by looking for it themselves, or passively, by encountering it serendipitously). These were accessing, chaining, monitoring, surveying, *searching*, *browsing*, and *encountering*. In this article, we discuss only the behaviors in italics, with example excerpts from the observations. We also make reference to the behavioral subtypes identified related to each behavior (where appropriate). As justified earlier, we focus on "searching" at the "image" and "video" levels and on "browsing" and the "video content" levels.

***Searching** (for textual content, documents, **images**, and video)-"Formulating, submitting, editing and filtering queries" (adapted from Makri, 2009).*

The MArch students all used Google as a search tool. Most commonly, they searched for *images*, always using Google Images search. However, it was also fairly common for them to search Google for *documents* (including Web pages). Many students also used Google Video search to search the YouTube collection, or searched YouTube directly for *video*. Finally, some students searched *within documents* (i.e., to find mentions of a particular word of phrase or their search terms).

As in Makri et al. (2008), we found that searching behavior can be further broken down into a number of subbehaviors, as follows: *search formulating*, *search editing* (which encompasses generalizing, specializing, reformulating, refocusing and correcting queries), and *search filtering*. In this section, we provide examples based on their *image* searches, as this was the most common type of search conducted. However, the MArch students also displayed similar search behavior when searching for documents and video, presumably because of the fact that the same search syntax could be used to search for different media types. The only noticeable variation in search behavior across media was when searching at the video level. At this level, search queries tended to be less complex and students did not tend to edit their queries once formulated, unless they thought they had made a spelling error or their initial search did not seem to bring back relevant material.

Almost all MArch students had difficulty with formulating search queries that expressed their information needs in a way that was likely to yield useful search results (search formulating). This seems to be the case with students from a variety of disciplines (see Buchanan et al., 2005; Makri et al., 2008). Although some of the students were unaware that they were having search difficulties, others were aware of their difficulties but unaware of how to alleviate their difficulties (i.e., how to improve their search queries). This urban design student was an exception. When her Google Images search for "London 2100" brought back few images of how London might look in the future, she realized that the term "2100" might be causing the problem and changed her query to "future London" and subsequently found useful images:

> P4: I'm doing an urban fiction, which is a city I'm designing 100 years after. I've chosen London as my city [loads Google Images and searches for "London 2100"]. That's my project title, but you can see that there's nothing here. By 2100, I meant to get something in terms of an overview of a city—images of the future. [reformulates Google Images search to "future London"].

Despite the fact that only few of the submitted queries brought back useful results, the MArch students rarely *edited* their search queries, instead preferring to continue to look through the results list returned from the initial query. This contrasts with the academic lawyers in Makri et al. (2008), who commonly edited queries when they were not happy with the results. When the students did edit their search queries, the most common change was to *reformulate* the query again from scratch (as in the example above). Evidence was also found of *refocusing* queries (adjusting the focus of the existing query by adding, removing, or changing some, but not all, of the terms). We also observed MArch students *correcting* search queries. Search queries can be corrected by changing the spelling of query terms, the syntax used to connect terms, or the syntax used to define the scope of the search. However, the MArch students performed only the most basic of spelling corrections, always spurred by Google's "Did you mean?" suggestions:

> P1: Google, I really like it. [. . .] Sometimes I will even spell a name wrong, but it will show me a correction. [Google Images suggests changing the search to "Zaha Hadid" and P1 accepts this suggestion].

Whether reformulating or refocusing their queries, two techniques that the MArch students demonstrated (which can be considered subbehaviors in their own right) were *generalizing* and *specializing*. Making a search query more general usually involved removing or changing search terms with an aim of retrieving a broader set of results, while making a query more specialized usually involved adding or changing search terms with an aim of retrieving a narrower set of results. In this example, an urban design student changed her Google Images search for "Paris" (which brought back images of celebrity socialite Paris Hilton as well as of the French capital) to "Paris images." The student seemed unaware that her specialization attempt had been unsuccessful; although the new search still brought back roughly the same number of thumbnails of Paris Hilton in the first two results pages, the student

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asserted that the search for "Paris images" had provided "a few more images" of the city:

> P7: At the beginning, as I had not been to Paris before, I wanted to get images of Paris to help me understand what Paris looks like. Instead of looking at the Web, the first step I would do is click on "images" [searches Google Images for "Paris"]. Then you will also see some of the types of images that you're not looking for [points to images of Paris Hilton]. So, it's kind of annoying. So, then I'll type "Paris images" [refines original image search] and then you've got a few more images of Paris.

As can be noted from the, often subtle, differences between the original search terms entered by the students and the edited versions in the excerpts above, the search edits made did not usually produce a more useful set of search results. Instead, they usually produced an alternative set of results that, although still related somewhat to the students' requirements, did not stand out as being any "better" than the previous set. This suggests the MArch students could benefit from human or technological support in not only formulating but also editing queries.

The MArch students also *filtered* their search queries (although this was also rare, and observed only for Google Images searches to ensure a high-quality image was selected in preparation for later use):

> P3: Sometimes if I need larger images to print out, some of these [points to Google Images thumbnails with cursor] are not good, so I'll go to "extra large images" [filters search by selecting "extra large images" from the "image size" drop-down box at the top of the Google Images results page]. So, the search engine filters.

Despite not being discussed by Ellis and his colleagues, searching is by no means a "new" information behavior. Searching is an important component of Marchionini's (1995) information-seeking process model and as early as 1979, Marcia Bates defined a broad range of "search tactics," many of which are similar to the lower level searching behaviors we have identified (see Bates, 1979). For example, Bates's "exhaust" strategy involves adding words to an existing query (similar to our "specializing" behavior) and Bates's "reduce" strategy involves minimizing or subtracting words from an existing query (similar to our "generalizing" behavior).

Similarly, Sutcliffe and Ennis (1998) proposed a cognitive process model of information searching activities that involves identifying an initial information need or goal (problem identification), expressing it as concepts or high-level semantics (needs articulation), and translating the concepts/semantics into a search query (query formulation). Sutcliffe and Ennis also describe a number of behavioral strategies for achieving each of the above stages. In particular, they discuss various strategies related to the "search editing" behaviors we identified among the MArch students, which included broadening or narrowing queries, stemming/de-stemming, adding or removing constraints (such as journals to be searched), and converting conjunctions into disjunctions and vice versa. Although all of these models are based on text searches, the same search behaviors were used by the MArch students when searching for images and video.

Encountering (documents)*-"Unexpectedly finding" (adapted from Oxford English Dictionary).*

The searches submitted by the MArch students sometimes resulted in serendipitous discoveries (which were also noted by Bennett, 2006). These occurred when students clicked on result hyperlinks that did not seem directly related to the search or when they were browsing Web sites related to the current search. In the latter case, the serendipitous discoveries were of documents or Web pages that were not directly related to the current search. For example, this urban design student was searching for information on what Paris might look like in 100 years and, while searching Google for "imagination of the city," stumbled upon a Web page with artwork by Janet Cardiff:

> P7: After 20 pages, I found an artist called Janet Cardiff that was mentioned in one of the Web pages and I found a piece of her artwork and thought it was interesting and wanted to see more.
>
> R: Was her artwork on Paris?
>
> P7: No, her work was about cities. Well, not really about cities. She's a photographer, so took several pictures of the street and people of the city. But I like the style, so I just remembered to go back to check what this artist had done before.

Similarly, this urban design student clicked on a thumbnail depicting a side view of a building that had come up as part of a search for "Lea Valley London." She viewed the image in the context of the Web page on which it appeared and noticed that it related to a proposal written by one of her favorite architects, Richard Rogers. She then browsed through the Web page and proceeded to download several Adobe PDF documents of Rogers' projects:

> P5: I love Richard Rogers, so once I'm here, even though I'm looking for information on Lower Lea Valley, this is like a master plan. So, you can see here on your right, all the master plan projects from Roger's office. So, for sure, I'll view other ones [clicks on a PDF related to another Rogers proposal]. I know it's not related to Lower Lea Valley, which is my main project, but here I can see all the master plans he has done and as I love him as an architect, I will be learning for sure.

The concept of serendipitous discoveries has been discussed in the broader information-seeking literature. Adams and Blandford (2005), for example, found that users switched between serendipitous browsing and searching. We also found a tight coupling between searching Google and browsing the Web pages returned by the search and argue that electronic tools should support not only interleaving these tasks (as argued by Adams & Blandford) but also the *extraction* of relevant information when browsing. Extracting behavior is discussed later as part of "assessing" information. Similarly, Blandford et al. (2001) found that users felt they were making progress in their digital library searches when they made

DOI: 10.1002/asi

useful serendipitous information discoveries. Encountering information did not give the MArch students a feeling of progress per se, but arguably something greater: a feeling of *inspiration* because much of the encountered information provided ideas for their current design project or for future projects. Inspiration is discussed as a key overarching theme at the end of this section.

Williamson (1998) and Erdelez (2004), among others, have discussed the opportunistic encountering of information. Particularly relevant to our findings is Erdelez's model of information encountering, in which a user switches from a "foreground problem" to a "background interest/problem/task" that is not currently addressed by the user's existing information seeking. The model involves the following user behaviors:

- Noticing—finding information potentially relevant to the background problem.
- Stopping—interrupting the original search process to examine the encountered information.
- Examining—assessing the usefulness of the encountered information.
- Capturing—extracting and saving any useful information.
- Returning—returning to the initial information search for the foreground problem.

The MArch students generally followed Erdelez's model when encountering information. For example, after P5 looked at a number of proposals by Richard Rogers and visited several other parts of the Web site hosting the proposals to find out more information about him, she returned to her Google Images search for "Lower Lea Valley" (the broad part of London she wanted to regenerate) and refocused her search to "Leamouth Peninsular," which she explained was a site in the Lower Lea Valley area she was considering basing her project on. Some of the MArch students, however, did not return to the previous information search after encountering information. Instead, they used the information encountered to adjust the focus of their subsequent searches. For example, after noticing the mention of installation artist Janet Cardiff in the Google results list for her search for "imagination of the city," P7 viewed some of Cardiff's artwork and then reformulated her Google search to "Janet Cardiff London" and looked for more examples of her artwork, which included some video clips. Then, rather than returning to her original search, the student decided to search for more video clips, this time using the keywords "Paris Illustration." This is an example of how information encountering can facilitate information exploration, which we now discuss as an important information behavior in its own right.

Exploring *(a topical domain)-"Finding information either without a predefined goal or to address a vaguely-defined goal" (own definition).*

Exploring was also found to be important for the MArch students and is a potential means for architectural students to encounter information and be inspired. Although a predefined goal is not necessary for information exploration, exploration usually involves setting broad goals, which might be extremely vague (such as "I'm looking for information on canals") or less vague (such as "I'm looking for information on the Regents Canal"). Exploring can facilitate information encountering, which, in turn, can potentially lead to inspiration. It is also possible to be inspired through information found during exploration (even if finding that information was not completely "unexpected" as it was related to the vague exploratory goal). Exploring can also be facilitated through a number of other information behaviors discussed in our background section such as "starting/surveying" (as it is possible to explore a new topical area to gain an overview of it), "monitoring" (as it is possible to explore a particular topical area to maintain an awareness of developments in it), "searching" (as submitting vaguely focused queries can provide a springboard for exploration), and "browsing" (as it is possible to explore an electronic resource, source or a particular topical area by semidirected searching). Palmer et al. (2009) also discuss the similar behavior of probing: "an exploratory strategy used by interdisciplinary researchers to find relevant information that falls outside their discipline or area of expertise" (p. 14). However, while probing involves finding information about an unfamiliar topical domain, exploring might involve finding information from either a familiar or unfamiliar domain (or anything in-between).

André et al. (2009) highlight that image searches are often conducted to "play" or "explore" with no end goal. They suggest "the visual nature of image search makes it very easy to become sidetracked when something else of interest catches their eye, even if the initial query is task-focused." Many of the students in our study did exactly that: branching off from their initial image searches to explore often loosely related or seemingly unrelated Web pages. As explained by one urban design student, exploring a topical domain that is loosely related to her design project is an important part of the creative design process:

> P5: Your project, your site might remind you of something you've seen or done before and you might start off by looking into that first before looking into your proper site. I think it also probably happens to all of us that we start off looking for information on our site and end up doing something completely different, even though it's somehow related to our project. It's easy to say, from the outside, "you're wasting time!" But it's not wasting time, it's part of the creative design process.

This quotation highlights that "exploring" a topical domain can potentially facilitate information "encountering." Not only does this illustrate the close-knit relationship between these two behaviors, but as the desired outcome of the student exploring the topical domain is to be inspired by existing work, it also illustrates that sometimes these behaviors can result in the arguably greater goal of providing inspiration. The key overarching theme of inspiration as both a driver and enabler of information work is discussed at the end of this section.

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Potential benefits and drawbacks of information exploration are discussed by this urban design student, who was searching for a particular type of industrial setup in Sweden that her tutor told her might be relevant to her project and came across a Google search result entitled "museums in Sweden":

> P9: Now, museums in Sweden is not something directly related, but just out of architectural interest, I might just go to the link even though it may not be related to my project. It happens many times when you're doing project work and you just wander off on the Internet doing something else.
>
> R: Does this kind of "wandering off" often end up being useful?
>
> P9: Not directly, but indirectly yes, in terms of gaining knowledge.
>
> R: Is that knowledge that you would then use later?
>
> P9: Yeah, it's part of general knowledge, general architectural knowledge. It could be some building by some architect, which I didn't know, but I saw it while wandering off. But then I know that this is interesting, this is nice; this is something that inspires me. So that way, wandering off helps. But sometimes one thing that happens is that you wander off for too long. So in a 4-hour Internet session, you've probably wandered off for 2 hours and you think "oh God, I've wasted so much time with this." Though it may not be literally "time wasted." But it's not on your project. That happens a lot with looking for architectural stuff on the Internet. You just wander off.

Exploration is an important component of Kuhlthau's ISP model (Kuhlthau, 1993) and Vakkari's theory of task-based information retrieval (Vakkari, 2001). Vakkari (2001) highlights that in both studies, background information was used to frame the task at hand and explore the general topic (p. 48). In Kuhlthau's model, "exploration" is presented as a stage in the information-seeking process, where her students had already chosen a broad research topic and now wanted to explore the topic and formulate a research problem. Exploration is included in the "prefocus" stage of Vakkari's (2001) theory. Recently, increasing attention has also been paid to studying exploratory searching. As explained by White and Roth (2009): "In exploratory search, people usually submit a tentative query to navigate proximal to relevant documents in the collection, then explore the environment to better understand how to exploit it, selectively seeking and passively obtaining cues about their next steps" (p. 6). White and Roth consider exploratory search to be a specialization of information exploration: "a broad class of activities where new information is sought in a defined conceptual area" (p. 6).

As we mentioned in the overview of our findings, the fact that the MArch students were in the early-to-mid planning stages of their projects might well have led to the identification of more "exploring" behavior, which might have otherwise been noted during the final stages of their projects. This assertion is supported by the findings of Pennanen and Vakkari (2003), who conducted a longitudinal study of psychology students preparing a research proposal based on a self-chosen topic and found that as the students became more familiar with their topic, they shifted away from expecting general information and towards expecting more specific information.

Assessing

When assessing the information they found, the MArch students performed four behaviors: *selecting*, *distinguishing*, *browsing*, and *extracting*. Selecting and distinguishing typically occurred when deciding which search result or results to click on. These behaviors can therefore both be regarded as specific ways of performing relevance assessment. Browsing and extracting occurred *after* a particular result had been chosen, and can be regarded as ways of performing document triage when discussed in relation to textual content. Both relevance assessment and document triage are discussed extensively in the information retrieval and information science literature (for example, see Harter, 1998; Buchanan & Loizides, 2007). Although extracting behavior straddles the higher level behaviors of "assessing" and "interpreting" information, it is discussed only once, in this section.

Selecting *(documents,* ***images*** *and* ***video****)-"Carefully choosing as being potentially useful" (adapted from Oxford English Dictionary).*

As with the lawyers in Makri (2009), deciding whether to click on a result link to a particular image or video was, most of the time, a binary choice for the MArch students, who almost always performed their assessments result-by-result rather than ranking the results and choosing only the most suitable result or results (as with distinguishing). Although the students tended to select video indirectly (by looking at metadata such as the video preview thumbnail), they tended to select images directly, by looking at the image itself (or a thumbnail of the image) to decide whether it might be useful. Selecting was performed several times by each of the students in our study.

For video, *direct selecting* involved watching all or part of the clip. For example, this architectural design student briefly watched two video tutorials on how to make a DIY body sensor kit:

> P6: This is research to see how people capture motion, so I've started to get some knowledge from YouTube. I know they use sensors on the body and I now want to know how they make this [briefly loads 2 video clips, then closes them].

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For images, direct selecting was far more complicated. As explained by André et al. (2009): "Image search is often more exploratory than Web search. Searchers may be looking for an image with a particular visual 'style,' with a predefined 'type' in mind, or with certain characteristics, and they may not be able to express those requirements until the desired image is found" (p. 5). Indeed, the MArch students selected images based on a number of criteria, which they expressed only after they had looked at the Google Images thumbnails:

- *Image style.* P5: This one [points to image thumbnail in Google Images results] is a section, so I would go for that one to see what it is. A section is a two-dimensional side view of buildings, where you can see the elevations.
- *Image format*. P4: Since I'm an architect and this showed buildings, I clicked on it. But it looks as though it's been created by a graphic designer, and since I'm an architect, I'm more drawn to an aerial view of the city. So, that's what I'll look for [clicks on an aerial image].
- *Image content.* R: Why did you click on that one? P4: Because that's one of the craziest! It's a really extreme futuristic image. I'm doing this just to have an idea of what space is good, because it's related to my project. So, maybe I'll just have a look at it [clicks on another image thumbnail and locates image in document text].
- *Image properties* (e.g., image size, quality, level of detail). [Clicks on a Google Images thumbnail]. R: Why did you click on that one? P7: Because you can see the Eiffel Tower which, for me, is iconic. Buildings are especially good for representing a place like Paris. But I think the quality of this image is not good enough, so I'll choose another picture of the Eiffel Tower [clicks on another image].
- *Familiarity with the image*. R: How are you deciding which thumbnails to click on? P4: That's very interesting. I don't know! This one [points to thumbnail with cursor] because it seemed kind of familiar—I thought I had seen it before. That's why I clicked on it. And I was going to click on this one [points to another thumbnail with cursor] because I've watched some movies, so maybe those images in my mind that are already there of future cities are making me look for similar information [clicks on thumbnail].

Students *indirectly* selected videos by the looking at the video titles or thumbnails. One student, for example, used moving (as opposed to static) thumbnails to help her decide which "special effects" might be useful for her when creating her own project video on what a future Paris might be like:

> P7: I'd also probably use this one as well [points cursor over another movie preview thumbnail, entitled "Earth Zoom"] because it's related to a city. It lets you view the earth and zoom in and out like with Google Earth. I think I won't just focus on the style; I will also look for effects that are related to the topic, so this one seems useful.
>
> R: Are you looking at any of the titles or text, or are you just using the movie previews?
>
> P7: Just the video preview because for this, you can get information more quickly and clearly about what a particular effect can achieve rather than just reading about it. You can just see it and get it! For example, if I looked at the title "camera projection," you can't really get what it means just by reading.

As Google Images provides limited image metadata, images were selected indirectly either by the text above the thumbnail (which is automatically extracted by Google based on text on the source Web page the image comes from) or by the image URL. This architectural design student, for example, tried to use a Google Images search to find information on a forthcoming mobile art exhibition and selected images based on both keywords and URL:

> P1: I didn't know which result to click on, so I changed to "images" and it says "mobile art will arrive this summer in London" [reads image title snippet and clicks on image]. Normally, I would just click on the first image, but as the first one was a t-shirt, it was not what I was looking for. Also, this other image, I can read the words and I'm guessing it won't be useful. I think the Web site will talk about a building, but not about the exhibition. And I think this one [moves cursor over another image thumbnail] could be the same, because they're from the same .com Web site [highlights the domain names on both thumbnails to illustrate they are the same].

Although the MArch students selected documents in similar ways to those found in our study of lawyers (see Makri, 2009), none of the lawyers looked for images or video. Similarly, no use of multimedia was mentioned by Meho and Tibbo (2003) and the behavior-focused studies by Ellis and his colleagues reviewed in this article were all conducted before the widespread availability of multimedia content.

Distinguishing *(documents and* ***images****)-"Ranking according to relative importance" (adapted from Ellis, 1993).*

Although selecting was far more common than distinguishing behavior when assessing digital objects, many of the MArch students in our study also ranked search results according to their perceived relative importance. As in previous studies of electronic information behavior (see Makri et al., 2008; Makri, 2009), the students primarily distinguished between documents based on the title and relevant snippet in search result listings. However, distinguishing was far more common when assessing images as opposed to documents, perhaps because "images emerge as relevant through juxtaposition" (Elliott 2002, p. 194). We did not find any evidence of distinguishing between video clips, however. This might be because of the fact that the MArch students looked for documents and images more than video, or because none of the information tasks that involved video searching are likely to have benefited from ranking clips (especially when a clip might be useful even though the thumbnail or other metadata did not look promising or vice versa). We hypothesize that video distinguishing might be particularly useful for routine information tasks, where it is clear from the thumbnails/metadata whether the video is likely to be useful.

As with selecting behavior, the same direct/indirect subtypes were identified with distinguishing and they were accomplished in the same ways. When ranking images based

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on relative importance, the MArch students used the same criteria that they used for selecting:

- *Image style*. P7: Once I chose the first illustration image, I was looking for a similar style. Definitely these are not free hand-drawn [points with cursor to several other thumbnails of illustrations of Paris that are not hand-drawn].
- *Image format*. P3: I'll go through this results page and say that I'll click on this, this, this [points to all thumbnails that show graphs or charts] and not these [points at thumbnails that do not show graphs or chart]. Thumbnails are very important. They save my time.
- *Image content*. P6: In this case, I only wanted to click on pictures that relate to the body and new presentation to fashion design.
- *Image properties* (as with selecting, image size, quality, level of detail, etc.). P1: This time, I chose the pictures that were related to the book by selecting the ones that showed the book cover. So, I clicked on all three images of the book cover, but chose this one [points to images] because the picture is quite big compared to the others.
- *Familiarity with the image*. P1: I knew from this page of results that these two pictures were promising. I looked at all the pictures first, but I knew that these two [points to two of the thumbnails] were related to her book, because I'd already seen her books.

Again, as with selecting, *indirect distinguishing* between images was achieved by looking at the text above the Google Images thumbnails. However, no evidence was identified of indirect distinguishing by URL. Also, as with selecting, to the best of our knowledge, no previous behavioral models of information behavior have been based on or validated by observing users obtaining multimedia content. However, finding and assessing multimedia materials have been discussed previously in the literature. For example, similar behavior to "image distinguishing" was also noted among the photo journalists observed by Markkula and Sormunen (2000), who often made a tentative selection of candidate images based on a number of selection criteria before making a final selection.

Browsing/extracting *(textual content and* ***video content****)-"Semidirected searching" and "systematically working through content to identify material of interest" (both adapted from Ellis, 1989).*

Extracting behavior straddles both higher-level behaviors of "finding" and "assessing" information. It is usually necessary to browse through content (whether textual or video) to identify material of interest. Therefore, just as browsing and extracting were performed together by the MArch students in our study, they are discussed together here, focusing on video (as opposed to textual) content.

As an example of direct browsing through and extracting from video content, urban design student P7, who was looking for clips of a future Paris, watched the first few seconds of a video, and then pressed the "stop" button as she realized the clip was of a children's story set in Paris, not of the city itself. Students browsed and extracted video content indirectly by using the slider bar to jump to parts of the video where the preview image looked interesting. This action was often performed several times when viewing a clip:

> P4: If I get bored, I'll skip through. Or if I realize that it's too long. But with this one we're watching, it looks as though we're half done. But if I find we're here [points to movie slider bar], then I'll drag.

Students also browsed and extracted video content indirectly by pausing and rewinding clips, as demonstrated by the same urban design student. The student noticed the text "20 years later" appear during a video she was watching and paused/rewound the clip to where the text was displayed, and then clicked on the slider bar several times to skip to various points in the video:

> P4: How many years later did that say? I didn't read it. [pauses and rewinds video clip to when the text appears]. Here, I feel I've kind of lost it. [. . .] I actually read here that it says "20 years later," so I thought okay, what was the first timeframe then?
>
> R: So that's what you meant when you said you'd "lost it"?
>
> P4: Yeah. So, I went backwards but I didn't really get the first bit of text, which said "based on this novel." But I didn't get it, so I just skipped through it.

Although both browsing and extracting behavior have been discussed by previous studies that have led to the derivation or refinement of behavioral models of information behavior (e.g., Ellis, 1989; Ellis et al., 1993; Ellis & Haugan, 1997; Meho & Tibbo, 2003; Makri et al., 2008), to the best of our knowledge, no similar studies have discussed browsing and extracting from video content. This is also rarely discussed by previous work specifically aimed at examining users' video-based information behavior. For example, Cunningham and Nichols (2008) discuss users' behavior when browsing video collections such as YouTube, but not when viewing a particular video.

Interpreting

The high-level behavior of interpreting information involved the MArch students performing *extracting* behavior (as discussed in the previous section), along with *visualizing/appropriating* and analyzing/synthesizing (not discussed in this article). Visualizing and appropriating behaviors are discussed together because they are highly related to one another.

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***Visualizing/appropriating** (a **topical domain**)-"Using and personalizing interactive visual interfaces that support the schematic abstraction of information" (adapted from Friendly, 2007).*

Although there is an entire field of literature dedicated to data visualization (see Friendly, 2007), to the best of our knowledge, visualizing and appropriating have not been previously discussed as information behaviors in their own right. In this section, we describe examples of the MArch students in our study using Google Maps (an interactive Web mapping resource) to help them interpret information on the topical domain related to their design projects. Interactive maps are an example of a type of *data* visualization (i.e., the schematic abstraction of information). Data visualization is distinct from *information* visualization, which involves creating a visual representation of *highly abstract data*, which *has no clear physical representation* (Gershon et al., 1998). The Google Maps interface presents geographical data schematically in both a "map view" (which displays a customizable interactive map) and a "satellite view" (which displays an aerial map).

This architectural design student describes using the "satellite view" feature in Google Maps (along with user-submitted photographs of the area) to decide whether to visit a particular building of interest. She also describes appropriating (i.e., personalizing) the map interface by "marking interesting buildings" that she later plans to visit:

> P1: I use Google Maps to see an overhead view of a building. If I know the location, or address, I will type in the postcode and zoom, zoom, zoom to see if a building is the one I am looking for. Google Maps is also useful as during my Easter vacation I went to Berlin and some other cities in Germany to look at a lot of architectural buildings, including some build by Zaha Hadid. She built her first project there, in the Vitra museum in South Germany. So when I went there, me and my classmate used Google Maps to search which kind of architecture we wanted to visit. So at first, we searched buildings that we had already found in a book to see the building and if it looks interesting. You can also mark interesting buildings. So, at first, we just looked to see if we wanted to visit a building by using Google Maps. Then, if I want to locate the building, I will zoom out and use map view and print it out. [. . .] Google Maps will also show that somebody took a picture around this area. So it's easy to identify if this building is interesting.

Using Google Maps to visualize and appropriate information was also demonstrated by this urban design student, who was looking for a suitable site for his design project on urban city farms. He demonstrated finding details of existing London city farms in Google and "adding bubbles" (i.e., placemarks) for each of them in Google Maps:

> P3: So this starts off as a blank map and through Web sites, I get some locations which I enter into Google Maps and then add bubbles and save them as a map. So, I'll start by naming the map after my topic, "agriculture shaping cities" [creates new custom map]. So, suppose I'm searching for city farms in London, I'll search for "city farms in London" and add them to a map [conducts search and adds placemark and title for "Vauxhall City Farm"].

The student explained that the process of visualization could help reveal trends that, in turn, can help motivate his design project:

> P3: You may get lots of information about where the city farms are located and their histories and opening times through the Web sites, but when you put them here in Google Maps, sometimes you will get a different kind of feel by having them on a map. You might notice something new. For example, this is the M20 area of London [points to wide area on Google Map]. If you notice, in the south of London there are no farms [points to a lack of placemarks south of the river Thames compared to those north of the river]. So, now I can use this map to make that statement that there are very few city farms in South London and I can use this information to say that we need more city farms in the south of London.

The same student also demonstrated using the "edit" tool within Google Maps to draw a polygonal boundary around his chosen city farm site and, hence, appropriate the technology to the needs of his design project (which required him to select a suitable 1×1 kilometre site in London):

> P3: This is Kentish Town City Farm, this is Kentish Town tube station, this is Kentish Town West station and I just mapped this area after I selected this site [points to a sketched polygonal area on the saved Google Map]. It's almost 1 km squared. So, what I did was use this "edit" tool and drew a line round to mark the kilometre boundary. Then when I exported this line to Google Earth, I got the area approximately.

Using

The MArch students in our study made use of information either by *editing* it or making a record of it (i.e., *recording* it). We now discuss these behaviors.

***Editing** (**images** and **video**)-"Preparing and arranging for later use by making revisions or adaptations" (adapted from Oxford English Dictionary).*

To the best of our knowledge, only document editing has been discussed in previous studies that have resulted in the derivation or refinement of behavioral models of information behavior (see Makri, 2009). However, instead of documents, the MArch students edited images and video. There were several ways in which they edited images. The first was by *modifying* them in some way. Many of the students mentioned using photo editing software to change aspects of the images they had found, or to make collages of several related images to show to their tutor. This urban design student, for example, came across a chart depicting the proportion of agricultural

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land use in Europe and suggested modifying the image to convey his vision of increased agricultural land use:

> P3: So, what I'll do is find something useful from a chart – for example, let's say that a certain part of Europe doesn't have much land for agricultural use close to major cities and let's say the chart I find shows agricultural land in green and the rest in white. I might redo the image in Photoshop to say "why can't this land be green," and make a version of the chart where I paint the white portion in green, so that graphically it says what I'm proposing.

Similarly, this urban design student mentioned selecting a particular image of the Eiffel Tower precisely because it would be easy to modify the image for use in her design project on a "future Paris":

> R: Why did you particularly like that one?
>
> P7: Because this one is clear enough to show the object which I was looking for, the Eiffel Tower.
>
> R: What makes it clear?
>
> P7: First, because it shows the whole of the building and not part of it. Second, if I use this one, it won't be too difficult to remove the sky and trees in the background, because we use other software like Photoshop to modify the images we find. In Photoshop, to use an image like this of the Eiffel Tower, you have to remove the background. In this photo, we can easily just cut it because the sky only has blue and white in it, it will be fairly easy to remove.

Another way the students edited images was by *redrawing* them. This was with a purpose of changing something about the original image. For example, this student describes redrawing a low-resolution image:

> P3: I might just redraw them in Photoshop only because here they are using bigger pixels. It's like tracing only. I'll keep the image and I'll redraw it. Or, if I have the basic idea about what information this image conveys. For example, I know on this map that they've shown information using different colours. I'll just redraw it. It's not difficult.

MArch students also edited images by *collating* them (often with the purpose of creating a collage to illustrate potential directions for their design projects that could be shown to their project tutor during supervision meetings):

> P5: It's a good aerial view for my proposal because I can place in here, later on, parts of my proposal, in 3D. This is good because it's an aerial view of the whole of London and you can see the river and the infrastructure. So, this is a really, really good image to do a collage. We tend to do lots of collages in urban design.

The final way the students edited images was by *importing* them into a computer-aided design package for later use:

> P5: You can download either images or maps to use in AutoCAD from all over the UK and that's really, really useful because you don't have to draw the map.

Students also imported collected or own images into animation and video editing packages to help them create video projects (an example of *video* editing). This urban design student, for example, spent time collecting images of Paris (including the image of the Eiffel Tower discussed earlier) and learning several video animation techniques to feed these into her own video clip of what Paris might be like in the future:

> P7: After I know what techniques to use, I will start making videos by myself. So, now, I have several images of Paris and I know from Video Co-Pilot how to make this stuff grow [points to animation of "title plate" effect]. So, I will probably use Illustrator or something to produce some hand drawings of Paris, then put them into After Effects and make the drawing grow up using this effect.

Recording *(a topical domain, resources, sources, documents,* ***images*** *and* ***video****)-"Making a record" (adapted from Oxford English Dictionary).*

Many of the MArch students mentioned or demonstrated making a record of information. Frequently, this was by downloading and saving (for documents and images) or adding Internet bookmarks (for resources, sources, and video). These common ways of recording documents were also noted in Makri et al., 2008. However, unlike the academic lawyers in our previous study, the architectural students also made use of Web 2.0 technologies for recording. For example, this architectural design student kept a blog (which was predominately image-based) to record both the process and the outcomes of his research:

> P6: In my blog, I separate some headings for research and I put my work there. My tutor will check my blog every week and I have to upload new work before tutorials, so we can discuss the work when I'm in tutorials. [. . .] [Loads personal blog and shows images]. For example, here's the page on my blog, which shows the tests I did with laser light and a camera in my home. This picture shows the light tracing and was inspired by the image I showed you earlier using laser lights.

In general, however, *images* were recorded by downloading and saving them, copying and pasting them into document text, or uploading them to a personal blog.

A record was kept of *videos* by bookmarking (rather than downloading them), most likely because of their large file size. Some students also mentioned adding links to YouTube videos to their blogs and sharing them using social networking sites such as Facebook.

Much of the early literature on architects' information behavior found widespread use of personal information collections. The downloaded documents/images and Internet bookmarks can also be considered personal collections of a sort; indeed, most MArch students kept collections of downloaded documents and images and Internet bookmarks. These collections of "downloads" and bookmarks often included items of interest that did not directly relate to the students' design projects. Although Palmer et al. (2009) discuss the organization of personal collections as a distinct information behavior, there was little evidence in our study of extensive organization of these collections of downloads and

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bookmarks. This might be because the students either rarely organized the information they found or were not using their own computers to perform their chosen information task (and, therefore, did not have ready access to their personal collections to demonstrate organizing information). The students' blogs can also be considered a type of *shared* collection of sorts, as students often viewed each others' blogs for inspiration and periodically talked about their own blog with their tutors. Although their tutors often encouraged the creation of these blogs (and, therefore, we do not know how far the use of blogs can generalize outside this population of MArch students), their creation is in direct contrast to the "hoarding" within personal collections described by Goodey and Matthew (1971) and Powell and Nichols (1982). Indeed, it can be argued that shared collections such as blogs and other Web 2.0 technologies such as social networking sites have the potential to make "collection" behavior among architects less inward and more outward-facing.

Communicating

The final high-level behavior identified in our study of architectural students was communicating. This involved, *sharing* information with others and *distributing* it. Communicating also involved consulting with colleagues, tutors, and domain experts, but this behavior is not discussed in this article.

Sharing/distributing *(information about a* ***topical domain, resources, sources, documents, images*** *and* ***video****)-"Giving out and obtaining from others" (adapted from Oxford English Dictionary).*

Sharing information with peers was also a common occurrence among MArch students, who shared not only information about topical areas but also details of electronic resources and sources deemed to be useful, as well as individual documents, images, and video clips. The students often used blogs to "discuss ideas and help each other with next steps" (P5). They also shared *topical domain* information through discussions in the studio:

> P1: I really like my classmates, because we like to share with each other. We will discuss our projects with each other. Normally, we work in the studio, so sometimes we will discuss what work each of us is doing. Or maybe I've been to a particular art gallery. Maybe that exhibition could be linked to one of my classmates' ideas.

They also shared details about *resources* and *sources* with each other by e-mail and on blogs and social networking sites. Project tutors also shared recommendations of resources and sources with their students, as explained by this architectural design student:

> P1: So in the beginning, our tutor just gives us some [pauses]. Well not some. My tutor is really fantastic. I really like him because he gives us a lot of sources, a lot of films, video from YouTube. [. . .] For example, once I received an e-mail from him and he sent me a link to a video on YouTube. Another time, to somebody's blog that he thought was interesting or to a Web page for a particular architect.

The same student mentioned receiving a document from a classmate who was accompanying her on a trip to South Germany, containing details of potentially interesting buildings that they might visit on the trip:

> P1: [My classmate] always looks at Web sites about new architecture around the world. He saved this information from the Web site and sent me an e-mail with it because we always cooperate with each other.

Images and *video* clips (particularly those detailing the process or outcome of the students' design projects) were usually shared on blogs or social networking sites. For example, this urban design student mentioned posting images related to her project on the Regents Canal on Facebook to share them with (and elicit comments from) a broad range of people on her "friends list":

> R: Once you'd saved [the images], what would you do with them afterwards?
>
> P8: If some of them are interesting, sometimes I put them in Facebook, because I quite like interacting with some of my friends, especially when they say something about the pictures that I've found. [. . .]
>
> R: Might your colleagues from your course then add comments to the photos?
>
> P8: Yeah, my friends from university and my parents' house. And some of my friends from my [hometown] and other towns. Because it's quite interesting to see what my friends from around the world think about these pictures, or these ideas.

Note that the above example relates more to sharing rather than consulting as consulting usually involved seeking information or advice from those with some *domain expertise* (i.e., peers, tutors or other domain experts).

The importance of sharing for architectural students was echoed by an architecture subject librarian, who explained that architectural students, including the MArch students in our study, undergo a critical review (CRIT) process when working on a design project. She explained that the process involved presenting the design work to an audience (including both design critics and fellow students), who would discuss and give feedback on the work and how to improve it. She suggested that sharing information worked hand-in-hand with the CRIT process:

> L2: The fact that architectural students seem to share lots of information reflects the CRIT process, which is probably the basis of architectural education in that your projects are

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> criticized by a review panel and your peers and it's the way that students learn and it's a very much a two-way process. So, the behaviors that you're finding do very much reflect the fundamentals of architectural education.

Sharing is rarely discussed in the information behavior literature, and, in their review of behavior across domains, Palmer et al. (2009) found "little evidence of sharing practices" (p. 16). However, the practice of information sharing is often discussed in the context of collaborating (see Twidale and Nichols, 1998, as an example) and was previously found to be important for architects by Elliott (2002). Talja (2002) describes four different types of information sharing:

- *Strategic sharing*: consciously sharing information as a means of maximizing group research efficiency.
- *Paradigmatic sharing*: sharing information as a means of establishing a novel and distinguishable research approach or area.
- *Directive sharing*: sharing information between teachers and students.
- *Social sharing*: sharing information to aid relationship and community building.

The MArch students in our study mostly performed "directive" and "social" sharing, obtaining information from their tutor shared on an individual or group basis (as in the quotation from P1 above) and obtaining information from each other, often facilitated by Web 2.0 technologies such as blogs and social networking sites (as in the quotation from P8 above). Although "social sharing" may well aid relationship and community building, the MArch students' primary purpose for sharing information was to help each other generate ideas and be inspired—an important overarching theme discussed later in this article.

Key Overarching Theme: Importance of Images and Video

Aside from the information behaviors that we have discussed, two important overarching themes emerged from our observations. These were the importance of images and video for architects and the theme of inspiration as both a potential driver and outcome of their information work.

Although, to the best of our knowledge, no previous studies of architects' information needs or behavior have found extensive use of video material, Frank (1999) noted the use of videos in a study of studio art academics. The artists stated that they sought videos for creative stimulation and technical instruction (i.e., learning various art techniques from student-produced and commercial videos). This was also the case with the architectural students in our study. Similarly, Markkula and Sormunen (2006) noted that television journalists made extensive video searches when generating ideas for and planning a television program. The importance of images for architects has been discussed more frequently (see our earlier discussion of the studies by Elliott, 2002, and Bennett, 2006). In a study of car designers' information use, Mougenot et al. (2008) also found images to be particularly important as compared with text, suggesting that images may be important for not only architectural design but also wider design disciplines. Images are also particularly important in other creative disciplines such as art and photography, suggesting that aspects of our findings related to image-based behavior may well generalize beyond the architectural domain. This, however, remains a hypothesis to be tested.

During our observations, the majority of Internet searches performed by the MArch students were image or video searches. Indeed, some of the students even searched for Web pages using a Google Images search (i.e., by clicking on an image of interest, locating the image in the context of its original Web page and then browsing the page). Many of the students made unprompted comments concerning the importance of images during the observations. They attributed this importance to the *visual*, *timesaving* and *mnemonic* nature of images as compared with text. Several students mentioned being "visual" by nature as a reason for preferring to look for images rather than text. This urban design student explained that she often ignored the text in Web pages and books and looked only at the images:

> P4: For me, I work more with visual things. I don't even read. So, if I see an interesting image, I'll just click on it. [. . .] If a book has lots of images, it's good! And I have talked to many people and, at least in my profession, they all say that they all like getting images by looking through books.

When probed further, the student explained that her preference for images was due to the fact that pictures can quickly convey information, whereas text often required detailed reading to understand it. Other MArch students also mentioned the timesaving nature of looking at images. For example, this urban design student explained that looking through Google search results "takes time" compared with an Images search:

> P3: Searching images is better than searching the Web if I don't have time [clicks on "Web" tab in Google]. Looking through all of this text takes time. There are a lot of words. So, for us, generally what we do is go with the images.

Finally, the mnemonic nature of images was mentioned by this urban design student, who explained that if an image of a particular project had been provided on the design consultancy WSP's Web site, then it would have provided her with a useful means of discussing the project with others (by using the image as an conversational anchor):

> P9: I know the firm WSP and I know somebody working there, so had there been an image of this, when I next meet my friend, I could have told them, "You know that WSP project which has this tall linear building with a narrow corridor." Something visual. But now all I can say is, because I'll never remember the name of the project, I'll probably just say, "I read about some industrial plant in Sweden or something like that." Most Architects do talk of buildings that way. "Oh, have you seen the building with that feature?" It's very visual. [. . .] Somehow you can remember images better. I don't know, maybe because visual memory is better or something like that.

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Key Overarching Theme: Inspiration as a Driver for and Outcome of Information Seeking and Use

The second key overarching theme that emerged from our data was that of inspiration as both a potential driver and outcome of information seeking and use. The need for inspiration was widely mentioned by the MArch students, who often performed introductory image searches on topics connected with their design projects during the early planning stages of their projects to generate ideas and be inspired:

> R: What have done so far with this project?
>
> P8: I wrote a little two-page report and looked for some pictures of existing canyons—just looking for some inspiration.

As Mougenot et al. (2008) explain: "A rather 'loose' Google search can be useful in retrieving related terms that the designer did not have in mind but are inspirational." This claim was supported by architecture subject librarian L2, who explained that "for us as librarians, we expect architectural students to be comprehensive in their searching, but particularly for the use of images, they want to be led to and to come across things and for things to inspire them, which a comprehensive search wouldn't necessarily do."

Inspiration was discussed as a potential driver not only for information work, as in the previous example, but also as a desired outcome (i.e., a potential result of performing any of the lower level behaviors discussed earlier). Inspiration was stated as a desired outcome for both generating design *solutions* and making design *process* decisions. For example, this architectural design student explained that he would often browse his classmates' blogs for inspiration on possible "next steps" in his design project and to learn the design process used by his peers:

> P6: My colleagues also look at my blog. I include links to all of my colleagues on my blog and maybe they put links to my blog on theirs.
>
> R: Why is it useful to look at a colleague's blog?
>
> P6: Because when you view a blog, you can think of the next step of what you can do for your own research. So, sometimes you just browse your friend's blog and see what they are doing. Maybe they can inspire you by giving you a new idea. It also helps you to know how people are thinking—their design process.
>
> R: So, you can get inspiration about both ideas for design and the process of design?
>
> P6: Yes, but our design project is very individual. For example, this colleague [clicks on link within blog to a classmate's blog] has done more work, so has put a lot of the design process here; so it would be useful to look at it in detail to learn about the process.

At all stages of their design projects, the students were inspired by images both *directly* and *indirectly*. *Direct* inspiration was gained from the content depicted in the images. This was often combined with previous experience to trigger a thought or idea, as illustrated by urban design student P8. The student was looking for pictures related to her project on the Regents Canal, and when she found images of the canal being used for horse-drawn traffic, she had the idea of including horses in her proposed regeneration of the canal. This idea was reinforced by her experience visiting the Turkish island of Büyükada, where all transportation was by horse and carriage. As explained by another urban design student P7: "What influences our imagination is our previous experience. Your imagination actually builds on what you have experienced before."

MArch students were *indirectly* inspired by images when it was not the content but other attributes of the image (such as its format or style) that sparked a thought or idea. For example, this urban design student explained that she planned to mimic the freehand illustration style she had seen in an image returned by one of her Google Images searches:

> P7: I see this one [points cursor at Google Images result] and it makes me think that it's a good idea to make an illustration out of a real image. I would now check for "Paris illustration" [conducts Google Images search] and then other illustrations come up. [. . .] The image only gives you ideas. I like this kind of freehand style and prefer this hand-drawing style. I won't use this image directly, but it will just give me ideas for doing something similar by myself.

As explained by another urban design student, looking at material that was not directly related to her design project (in this case an animated video clip) during the planning stage of her design project had the potential to lead to inspiration sometime in the future:

> R: What value can you gain from watching a video like this which, at first glance, seems unrelated to what you're doing?
>
> P4: It's just for ideas. I'll have this video in my mind and when I'm producing my own stuff, something will just click, you know. Something from all the images stored in my head.
>
> R: Is it the case that nothing, within reason, is useless?
>
> P4: Yeah. If I'm working or trying to present something, then I'll be like "I saw that kind of thing before." It might just be a starting idea, or it might just fit in somewhere. I mean, I don't get any theory from here, so I can't just use the concept. But from that video, the guy sketching his stuff and the buildings that were moving, maybe I could think about showing another piece of work in a similar way.

Although we found that MArch students could be inspired while performing a range of lower level information behaviors, inspiration was most often an outcome of "encountering" or "exploring" information. Urban design student P5, for example, explained that she often ended up moving far away from her initial research goal because architects are "interested in almost everything" and "can have inspirations from so many different things." Inspiration was also related to the concept of originality. As explained by architectural design student P1, the aim of practical work such as his design project was to enable him to "develop [his] own style" rather than copy or mimic the work of others. As explained by an urban

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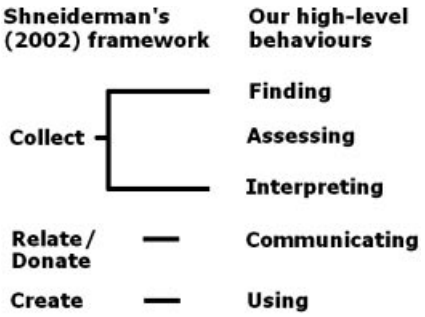

FIG. 3. How our higher-level information behaviors relate to Schneiderman's creativity framework.

design student, it is possible to be inspired and influenced by other peoples' work without copying it:

> P7: Famous Architects have their own styles of work and once you make something very similar, people will suddenly recognize that you've copied from them or doing this because you're influenced by them. Being influenced by others, I think is okay. Because I'm always influenced by other people. Other people inspire me. But for architectural design, producing something original is very important. That's why, at masters level, you're being influenced by other peoples' work, not just copying it.

The importance of inspiration among the MArch students in our study is closely linked to the concept of creativity (and the creativity framework by Schneiderman, 2001 described earlier). For example, it is possible to relate each of the five higher-level behaviors—finding, assessing, interpreting, using, and communicating—, which we identified in our study, to Schneiderman's Genex framework (see Figure 3). When performing Schneiderman's activity of *collecting* information, we are effectively *finding*, *assessing*, and *interpreting* it. Indeed, we observed each of the potential information tasks described by Schneiderman as part of "collecting" (searching and browsing electronic resources, visualizing data and processes) and categorized them under the three higher-level behaviors above. Similarly, Schneiderman's activities of both *relating* and *donating* information are highly similar to our *communicating* behavior. Just as Schneiderman's "relate" activity involves "consulting with peers and mentors," we identified consulting as a lower level communicating behavior. Similarly, Schneiderman's "donate" activity, which involves disseminating work, corresponds to the lower level communicating behavior of "distributing" that we identified. Although Scheiderman's *creating* activity (which involves "exploring, composing and evaluating potential solutions"; Schneiderman, 2001, p. 214) does not directly correspond to our *using* behavior, it can be argued that our lower level information use behaviors of editing and recording can help facilitate a creative outcome. For example, editing images related to a design project can be considered a way of "composing" a potential solution. Similarly, recording information about a topical domain (or about search queries used) can potentially support reflection (part of Schneiderman's definition of the "create" activity).

The importance of inspiration for architects during the early-to-mid planning stages of their design projects suggests the need to support creativity when designing electronic resources aimed at supporting information seeking, interpretation and use. In the final section of this article, we make suggestions for how electronic resources might support the lower level behaviors identified in our study in ways that might encourage and foster creativity.

Implications for the Design of Electronic Resources for Architects

As illustrated by Ellis (1989) and Makri et al. (2008), it is possible to use empirically identified information behaviors as a framework for making design suggestions for how electronic information resources support or better support particular behaviors. However, given the importance of inspiration for the MArch students, we suggest that electronic information resources should also encourage and foster creativity wherever possible. Supporting creativity and the lower level behaviors we identified and creativity need not be separate endeavours. Indeed, we suggest that it is possible to support creativity, albeit indirectly, by ensuring that electronic resources are designed to support the lower level behaviors identified in our study in ways that might lead to creativity. In other words, we suggest that designers of electronic resources for architects should ask themselves not only "How can we design to support or better support the information behaviors that architects perform?" but also "How can we design to support or better support these behaviors in ways that encourage creativity?" We now present design recommendations for many of the lower level behaviors we identified (especially those found to be particularly important for the architects). We focus mostly on suggestions to support architects finding, assessing, interpreting, using, and communicating *images* and *video*. This is partly because of the importance of these media for architects and partly because these media are, in general, not well supported by current electronic information resources, across the entire range of behaviors identified.

We suggest it is possible to design "creative" electronic resources for architects that support or better support the following:

- *Searching:* by providing user tagging functionality (allowing users to search then browse similar user-tagged Web pages, images or video clips); by providing a thumbnail snapshot of Web pages alongside search results; by providing thumbnails of various images contained in a Web page alongside search results.
- *Browsing:* by providing the functionality to "jump between" images/videos on a Web page in a similar way to jumping to instances of particular text; by providing the functionality to browse for images or video with a similar style, format, or content (these images/video may need to be user tagged as current image retrieval technology does not match human tagging abilities); by providing the functionality to browse for images or video hosted by the same Web site, produced by or depicting the work of the same author/architect, etc.

DOI: 10.1002/asi

- *Exploring* and *encountering*: by providing the functionality for users to categorize, rate and provide short descriptions of resources, sources, documents/Web sites, images, video, etc., and to view material categorized/rated/tagged by particular people (e.g., a tutor or particular colleagues); by integrating images/videos uploaded to social networking sites such as Facebook with image/video search results (i.e., including uploaded images in image search results, where relevant). Both the Flemenco (Elliott, 2001) and Tendrill (André et al., 2009) image search tools allow users to find additional images that share similar metadata to the current image. Tendrill also presents a selection of opening images to "highlight the exploratory (and not pure keyword) search experience, as well as to facilitate serendipitous browsing" (p. 11).
- *Selecting* and *distinguishing*: by implementing the design suggestions for browsing for similar images/video already mentioned under "browsing"; by providing moving thumbnail previews of video clips that display images from various points during the video when the user holds their cursor over the thumbnail.
- *Visualizing* and *appropriating*: by displaying thumbnail images from hyperlinked Web pages dynamically and visually, perhaps with snippets of the text surrounding each image when the user holds their cursor over the thumbnail; by providing functionality for mapping sites such as Google Maps to display placemarks based on user-tagged information (e.g., interesting buildings in a particular geographical area, related to a particular topical area, built/inspired by a particular architect, in a particular architectural style, etc.); by integrating information from the Web and user comments about buildings with mapping functionality.
- *Editing*: by providing easy import of images and video into editing packages (including computer-aided design packages); by providing simple online editing facilities within the browser environment (e.g., for cropping or removing the background in images, cutting sections from videos, or splitting them into several clips).
- *Recording*: by providing easy download of full-size images by clicking on thumbnails; by auto-importing downloaded images or videos into a library/editing package; by providing the functionality to store, organize, and comment bookmarks online (as provided by sites such as Google Bookmarks).
- *Sharing* and *distributing*: by providing the functionality to share organized online bookmarks with others; by allowing users to tag particular search results (whether textual snippets or image/video thumbnails) and import them into social networking sites, or share them in other ways, such as e-mail; by allowing users to tag the currently viewed Web site/image/video as "potentially interesting" for a particular person or group and to automatically share the URL with them by e-mail or on social networking sites; by providing the functionality to upload documents, images, or video and invite comments from peers (perhaps on a dedicated site for architects as opposed to on a social networking site); by providing the functionality to recommend sites, documents, images, or video clips to others (e.g., by e-mailing the relevant online shared bookmark to an individual or group).

The list of design suggestions we have presented is nonexhaustive and draws heavily on examples of Web 2.0 technologies, as we believe these have great potential to be exploited by developers of electronic information resources.

Conclusion

Overall, this work makes important practical contributions by identifying and discussing the important information behaviors performed by architectural students during a design project and related suggestions for the design or improvement of electronic information resources. We also make important theoretical contributions by further refining Ellis's behavioral model. However, there are many further opportunities for user-centred research that involves understanding architects' information needs and behavior in the context of their work, using this understanding to inform design and evaluating whether the resultant design interventions meet these needs and support this behavior effectively. Future challenges also lie in gaining an understanding of the broad information behaviors (encompassing information seeking, interpretation, and use) performed in a variety of lesser studied academic and commercial domains and feeding this understanding into suggestions for the design or improvement of electronic information tools or resources, or into prototype designs.

However, an arguably greater challenge lies in identifying and understanding behavior that might be but is *not currently* supported by electronic resources. This involves taking a step beyond observing what people *currently* use electronic resources for and instead trying to decide what functionality these resources should, in future, help them to achieve. This is far more difficult than it seems. Indeed, it is unlikely to be as easy as asking potential users to specify design requirements, as although potential users may have a sound knowledge of a particular domain and work context, they are unlikely to be aware of relevant technical possibilities and constraints or how particular requirements might translate into interface functionality.

Although a participatory design process (involving both systems designers and potential users) might go some way to addressing this difficulty, our findings suggest that it is useful to gain an understanding of not only the information behavior performed in a particular domain or work context but also the nature of the domain or context. This understanding can then augment the participatory design process to aid systems designers in developing information tools and resources with novel functionality grounded in the very nature of the domain in which they are being designed to support.

Acknowledgments

This work is supported by an ESRC postdoctoral fellowship. We would like to thank the MArch students and architecture subject librarians that took part in our study.

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