Supporting Task with Information Appliances: Taxonomy of Needs

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ABSTRACT
Integrating search systems with task environments to create task-specific information appliances will most likely represent the next wave of technologies. At present, search systems are for the most part isolated from the actual task environment. In this paper we have identified one task environment – that of the student writing a term paper – to propose sets of needs that should to be supported by tools. In addition, the process of completing the task illustrates how search needs change in level of specificity over the life of the task.

Categories and Subject Descriptors
H.3.3 [**Information Search and Retrieval**]: Search Process

General Terms
Design, Human Factors.

Keywords
Task, Information Appliance.

1. INTRODUCTION
As search engine giants such as Yahoo, Google, and Bing fight for market share, their search interfaces are moving away from the original simplicity of the search interface popularized by Google to offer more enhanced search options for users (e.g., filtering, visualizations). However, they still strive to meet the demands of the masses with a "one size fits all" interface and in doing so fail to address the specific, contextual, task-based needs of their users. Essentially, what is missing from the current search engine landscape are task-specific information appliances that embed search as a core function.

The term "information appliance," coined by Raskin in 1978, and popularized by Norman in 1998, is defined as "an appliance specializing in information…designed to support a specific activity" [2]. Information appliances are task-specific tools that support the varied cognitive processes involved in the execution of complex tasks such as patent writing, thesis topic development, environmental decision making and project management. Just as technologies such as the telescope have enabled us to extend our perceptual capacity to make discoveries and cutting edge creativity tools hold the promise of extending our creative abilities [6], information appliances have the potential to support knowledge work in all its stages from idea to outcome, supporting the work *flow* rather than isolated components of the work task.

Norman suggests that "making a proper information appliance has two requirements: the tool must fit the task and there must be universal communication and sharing" [2]. The system needs to integrate multiple activities to support the task as a whole [5]. Search is linked to task-centric processes; yet search is rarely fully integrated as exemplified by the way it is currently included in word processing and email applications. Perhaps the better implementations are within task-centric applications for travel and shopping that support highly structured tasks with very specific goals and known outcomes. However, with student term paper writing, for example, the topic may not be known and the outcome may be only known by its format rather than its content. One of the few to note the close intertwining of search with task was Vakkari [7,8,9] who additionally observed that students needed better support during the various stages of writing a thesis proposal.

Taking but one example from the pool of many task options, how can we support the student who is writing a term paper? In this paper we will outline the processes undertaken by students while writing a paper and illustrate how these processes map to functions and tools needed in an information appliance to support the student writing task.

2. Understanding the Problem
Kuhlthau's [1] model of the search process and Vakkari's [7,8,9] enrichment of the model form the basis for our description of the task which interweaves the search for information with the act of writing a term paper (see column B of Fig 1). Kuhlthau identified six phases of the information search process: 1) task initiation, 2) topic selection, 3) prefocus exploration, 4) focus formulation, 5) information collection and 6) search closure. Each of these phases needs a variety of tools so that the student gets to the final phase. While Kuhlthau stopped at search closure, Vakkari extends it to presentation; the task is not complete and a more iterative process will ensue that

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involves checking and re-finding information sources before the job is done.

Within the task process phases different types of information exploration occur that map to Marchionini's [3] look-up, learn, and investigate (see column A of Fig 1). Look-up encompasses a goal-driven search that may include fact retrieval and retrieval of a known item; learn activities include knowledge acquisition and comparison when the intent is likely to be less specifically defined; and investigate comprises analysis, discovery, and exclusion or negation. These three types of search tasks overlap: look-up activities may be embedded, for example, in learn and investigate activities. Each of the stages in the process will likely have a primary intent, with the other two forming a secondary or tertiary intent. For example, while the primary intent of the prefocus exploration phase is to learn about a topic, this stage may also include look-up and investigate activities. The process moves along a continuum from browse to search.

At the same time, within each phase, a series of needs occur that involve how the user interacts with the information at that stage in the process. Ideally, these needs will be met before the user progresses to the next stage. Those represented in column C (Fig 1) were devised from an earlier work conducted by speculating on the types of tools that are required to facilitate browsing [4]. The list is not meant to be complete but is suggestive; it indicates the types of tools that are required to *use* information. For example, at the prefocus exploration phase when the user is attempting to generate an understanding of the topic, there is a need to define or explain concepts, make connections among a set of information objects, and initiate some organization of the material as the topic unfolds. These are primarily cognitive activities performed by a user, but these are also activities that could be supported by technology.

Column D of Figure 1 identifies a sample of some of the tools that exist today, some of which may support some of the identified needs.

3. Mapping Tools to Process and Needs

To illuminate what an information appliance should be capable of supporting, we examined each phase of the task process, elaborating on the needs at each stage, as well as the types of information search and retrieval that are implicit to each. Figure 1 illustrates the relationships.

3.1 Topic Selection

During the *topic selection* phase, students identify the area and likely scope of the task – they are generating ideas. During this phase, students primarily engage in investigative searches to plan and forecast possible topics and interests. Investigative searches are iterative [3], and learning and look-up searches will be embedded in the process as students expand their knowledgebase and interests.

At this point, students make connections between their knowledge of the topic and the information encountered. Connections allow students to view information objects or topic areas that they may not have known were related; these may be more comprehendible in a visual form. Similarly, suggestions, which provide alternatives based on differing starting assumptions, may augment the available knowledge.

Both Vakkari [8] and Kuhlthau [1] suggest that consulting with mentors is a common strategy during topic selection. Collaboration enables information sharing and communication among students. The ability to discuss potential topics with colleagues can provide insight into which topics have been sufficiently covered and which areas require further exploration. Connected to the function of collaborative tools are discrimination tools which distinguish between desirable and undesirable areas of exploration.

At this point, other needs such as definition rendered by a dictionary define specific terms and how they are used while explanation elaborates on a definition [4], not unlike the role that Wikipedia performs at present. Similarly, simplification, a tool which minimizes complexity in a large body of information [4] can extract core elements that relate to a topic assisting the student in developing a comprehension of the area and additionally highlighting which sources will provide more general information. Students may also benefit from tools that allow them to organize and personalize their information space.

3.2 Prefocus Exploration

Prefocus exploration is conducted when students are attempting to select a focus within their chosen topic. Often, several possible foci will be weighted and decided upon based on personal interest, information available, and relevance to the assignment. Because subject knowledge is minimal, students need general background and theoretical information to move beyond this phase [8]. In order to retrieve general information, students are primarily engaged in learning types of searches for "knowledge acquisition, comprehension of concepts or skills, interpretation of ideas, and comparisons or aggregations of data and concepts" [3]. However, students exhibit difficulty conducting these searches because their limited subject knowledge hinders their ability to express their information needs [7,8]. During this stage students are more likely to have difficulty selecting the appropriate vocabulary and are less able to express their information needs through querying [7,8].

Once students obtain a basic conceptual model of their topic, prefocus exploration can be facilitated by functions which help them gain a deeper understanding of their topic. Various perspectives help students identify information that may come from many different viewpoints [4], and encourage them to think critically about the topic. Similarly, tools that encourage stimulation, divergence, promote idea generation, and enhance students' overall intellectual experience [4] would contribute to the development and refinement of students' mental models. As students' conceptual models of the topics mature, their topical vocabulary grows, and their ability to construct effective queries will develop. The result of this is an increased ability to identify and extract relevant and pertinent information sources [1,9].

3.3 Focus Formulation

During the *focus formulation* phase, students have a greater understanding of their topic and are ready to narrow their focus from a selection of the themes and information they encountered during the prefocus exploration phase. Students often review notes taken while exploring the topic to identify and combine

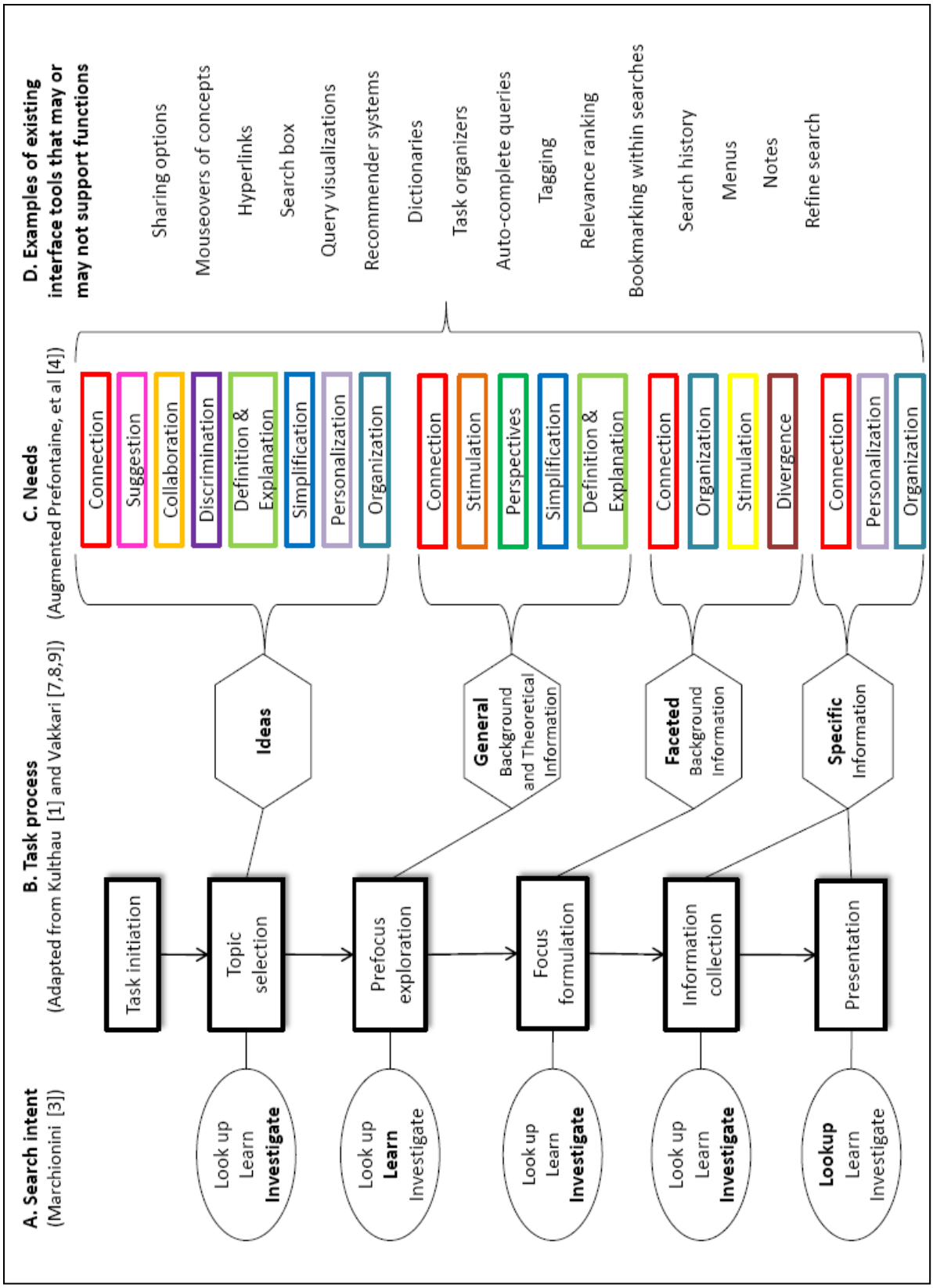

Figure 1 Mapping Tools to Process and Function

themes and ideas [1]. During this phase students need to actualize those "sudden moments of insight" [1] for creativity to be achieved, accomplished by enabling and promoting serendipity, and the making of novel connections.

Students conduct investigative searches to identify research gaps and critically evaluate topical information. During investigative searches, the intent is to maximize recall and retrieve a high number of relevant sources [3]. However, the proportion of non-relevant references increases as the search process matures [8,9] suggesting that the system should be able to manage and present the scope of the material involved in that topic. The general background information reviewed and learned during the previous phases provides students with a greater understanding of the vocabulary associated with the topic, enhancing their ability to use more and more effective querying strategies [7,8]. At the same time their conceptual model is not fully developed, and they continue to seek faceted background information about the broad sub-fields of the topic [8]. While the intent is to retrieve a higher proportion of relevant sources, students have developed a higher standard of relevance criteria. Precision searches, which intend to reduce irrelevant sources [3], are conducted as specificity becomes the dominant requirement.

Note taking and reviewing are core activities during this phase [1]. Organization re-structures information to make it more usable [4] and provides students with the option of organizing their own notes and annotations in a format that they can access and review. Suggestion and stimulation tools can encourage connection-making and focus development.

3.4 Information Collection and Presentation

When a student has decided on a focus, the *information collecting* stage begins. During information collecting, students actively engage in an investigative search for information that will support, define, and extend their selected topic [1]. But they also conduct learning searches to clarify information and expand their knowledgebase. During this stage, students have a more fully developed conceptual model of the topic and no longer need to seek general information; instead, they search for more specific detailed information that uncovers the central variable of the task [1,8]. To obtain specific information, students may once again consult with formal mentors and begin citation chaining. Functions that enable information collection include personalization which may help students find information related to previous search sessions and connection tools can help them relate this information to their current search.

At this stage, students tend to utilize more effective strategies with specific queries that use more synonyms, narrower and related terms, and are more likely to use words that interconnect the concepts such as Boolean operators [7,8]. Formal mentors are still consulted but information systems are heavily relied upon [8]. Students may benefit from organization tools as they make detailed notes, organize citations, arrange their thoughts and theories and synthesize ideas and information [1,8] more formally and likely in writing before and during final *presentation* [7].

4. Conclusion and Future Work

In his description of information appliances, Norman states that: "the primary goal is to design the tool to fit the task so well that the tool becomes part of the task, feeling like a natural extension of the work, a natural extension of the person" [2]. At present, search is just another tool among many and not integrated into a user's task interface as effectively as the functions and tools of a driver's car dashboard. The ultimate goal in most knowledge work is the acquisition of information to create new information or knowledge while enhancing the intellectual capabilities of the individual. This is as true for other types of knowledge workers as it is for students. Our intent is not to automatically generate a paper on a topic; it is about providing a useful tool kit that enables, in the case of our example, a student to learn and produce a product. The first stage in this process is identifying and understanding the process and flow involved in completing the task and determining the needs associated with each phase in the process. From there, an information appliance can be designed to incorporate the needs of the user with functions and tools. The challenge from a development perspective is in controlling the flow and type of information without controlling the user. At the same time, it is about introducing a useful set of tools, pseudo cognitive prostheses, which enhance and augment human capability.

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