Searching as Learning:
Novel Measures for Information Interaction Research

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ABSTRACT

There is growing recognition of the importance of learning as a search outcome and of the need to provide support for it. Yet, before we can consider learning as a part of search, we need to know how to assess it. This panel will focus on methods and measures for assessing learning in the context of search tasks and their outcomes. The panel will be interactive as the audience will be encouraged to engage in contributing their own experiences and ideas related to measures and methods to study learning as a part of search processes. Ideas and experiences with explicit and implicit indicators of learning and with evaluating learning outcomes will be shared during a dialogue between the audience and panelists. Outcomes from the panel discussions will contribute to formulating a research agenda for "search as learning." The outcomes will be shared with the audience (and the wider ASIST community).

Keywords
Search as learning; measures of learning in searching

BACKGROUND

As millions of people use search engines every day, the impact that searching has made on people's lives is enormous. For a long time, we have considered search systems as information retrieval technologies, which tends to emphasize that systems are there to help people find existing documents. Therefore, search is often characterized as finding information or matching of questions with answers. However, through searching, people not only interact with information or answers, but also engage in learning and discovery beyond information finding (Marchionini, 2006).

Search engines are currently optimized for look-up tasks,

not for tasks that require rich interactions with information. For example, many of the measures used to evaluate search systems assume that minimal interaction times and low user effort are optimal. Therefore, search systems are not doing the best job at supporting tasks such as searching in order to learn and searching in order to investigate (Marchionini, 2006). While there is a growing interest in exploratory search, little research has been conducted to examine how exploratory search could enhance and stimulate learning.

Searching for learning is not an entirely new idea. The intersection between searching and learning has long been investigated with respect to teaching youth about information literacy, focusing on information search and evaluation skills. Discussions and empirical findings have centered around "learning to search" (information search skills) or "searching to learn" (support for information interaction). In cognate fields, such as education and cognitive science, the associations between information interaction, often in the form of reading, and outcomes such as learning and comprehension have been central concerns (Kintsch, 1998); however, this connection has been neglected in information science. We believe that the information science community should start discussing the learning that takes place during searching and identify effective approaches to foster and support it as a key outcome. An important first step in this direction is to identify models and theories of learning that are applicable to search, and to derive methods and measures that can be used to assess when and how learning occurs.

THEME OF THE PANEL

This panel proposes to serve as a catalyst for a new research initiative on *searching as learning*. We believe that this is a new research agenda because it focuses on the impact, influence, and consequences of using search systems as learning technologies rather than information retrieval tools and techniques. Panelists will discuss means by which search systems can support and foster deeper learning in more explicit ways.

This panel builds upon the two reports from recent information retrieval workshops. In 2012, at the Second Strategic Workshop on Information Retrieval (SWIRL), participants proposed ideas for empowering users to search and learn (Allan et al., 2012). They proposed that

IR systems can and should play a more central role in helping people develop their search skills and in supporting deeper learning experiences. In 2013, several participants in the Dagstuhl Seminar on Evaluation Methodologies in Information Retrieval engaged in discussions about moving "from searching to learning" and emphasized the importance of learning as a search outcome (Agosti et al., 2013).

A particular focus of this panel's discussions will be on methods and measures to assess learning performance and experiences. In the field of information retrieval, relevance has long been the primary evaluation criterion. For the past two decades, a number of additional measures have been examined, including usefulness, utility, user satisfaction, and success (Kelly, 2009). However, a very small number of studies have developed measures to assess learning as a process or outcome of searching. Wilson et al. (2008) developed an explicit measure of learning in terms of fact and statement counting. Kammerer et al. (2009) employed topic analysis. Jansen, Booth, and Smith (2009) applied Anderson and Krathwohl's taxonomy of the cognitive learning domain to search tasks and concluded that learning theory better describes the information searching process than previous paradigms such as problem solving and decision making. The measurements used in their study focused on measures of search effort for learning such as queries per session, topics searched per session, and total time spent searching. Wilson and Wilson's (2013) study directly dealt with the problem of how to measure learning during the search process. Based on Bloom's taxonomy of learning (Anderson et al., 2000) – remembering, understanding, applying, analyzing, evaluating, and creation – Wilson and Wilson developed three levels of learning measurements: Quality of facts (D-Qual), Interpretation of data into statements (D-Intrp), and Use of critique (D-Crit). Their measure is intended to capture depth of learning.

While these previous studies certainly provide useful groundwork, we believe that more research effort is needed to develop a range of process and outcome measures of learning associated with searching. Such measurement might start with developing measures at the information retrieval level, such as variety of terms used, number of documents viewed, number of documents assessed, and time spent on assessment. In addition, measurements could be also developed at higher levels of search tasks by including diversity of information seeking strategies, searchers' self-assessed pre- and post-task knowledge level, searchers' cognitive load, and comprehension test scores (Agosti et al., 2013).

We believe that existing methods, measures and instruments for the assessment of learning in the context of searching are insufficient to embrace the research theme of "searching as learning." The panel will discuss explicit measurement of learning as well as implicit indicators of learning in searching. One of the motivations for this panel is to uncover a comprehensive set of measures, methods, and indicators which could capture learning in searching directly. The panel will also discuss measures and methods that could identify interaction patterns that lead to better or worse learning outcomes.

GOALS OF THE PANEL

The goal of this panel is three-fold:

(1) To present a research direction for searching as learning that proposes to reconsider the value of search systems in providing support for learning.
(2) To discuss methods and measures to assess learning outcomes during the search process and after searching is completed.
(3) To contribute to the formulation of a research agenda for "searching as learning."

Panel outcomes will be shared with the audience and the wider ASIST community.

STRUCTURE OF THE PANEL

To promote discussions about this new research initiative, it is critical for the panel to engage in discussions with the audience. The overall structure of this panel is to invite ideas and suggestions about searching as learning, focusing on methods and measures instead of presenting previous work that panelists have already completed.

The proposed structure of the panel is as follows:

- The moderator will introduce the panel and the theme of the panel and define key terms;
- Each of the panelists will give a short presentation about searching as learning, focusing on methods and measurements;
- While presentations are going on, the audience will be asked to submit two different colored index cards. On the first card, they will be encouraged to list measures that could represent learning outcomes from searching or learning process occurring during search. On the second card they will make note of challenges or obstacles to be overcome in assessing learning. The index cards will be collected;
- The moderator will read and classify the audience responses into themes and during this time the audience will be asked to share their thoughts and experiences regarding the measurement and assessment of learning;
- The moderator will report back the summary of diverse measures and methods proposed by the audience;
- The moderator will wrap up the panel by proposing future research directions.

THE PANELISTS

Each panelist brings unique expertise to the issues of searching as learning as follows:

Soo Young Rieh is Associate Professor in the School of Information at the University of Michigan. Her research areas include web searching behavior, credibility assessment, search effort, and information literacy games. Recently, she has co-authored a book, *Designing online information literacy games students want to play* (Markey, Leeder, and Rieh, 2014). Further information on her research is available at: http://rieh.people.si.umich.edu/. On this panel, she will present the relationships between efforts people invest into the overall search process and the evaluation of information in particular, and how search efforts are related to learning outcomes and experiences. She will moderate the panel.

Jacek Gwizdka is on the faculty of the School of Information at University of Texas, Austin. He applies cognitive psychology to interactive information retrieval and to design of search user interfaces. His recent projects include implicit assessment of mental states using psycho-physiological methods, (e.g., eye-tracking) and application of cognitive neuroscience tools (e.g., fMRI) to the study of cognitive function engaged in human-information (Gwizdka, 2013; 2014). More information on his research is available at: http://www.gwizdka.com. On this panel, he will talk about a method for implicit measurement of learning based on his previous collaborative research at Rutgers University (Cole, Gwizdka, Liu, & Belkin, 2011; Cole, Gwizdka, Liu, Belkin, & Zhang, 2013). The method takes advantage of a direct relationship between eye movement patterns and cognitive processes. Spatial–temporal patterns of eye movement can reveal changes in a person's knowledge during information search process, and hence enable measurement of learning.

Luanne Freund is Associate Professor at the School of Library, Archival and Information Studies, the iSchool at the University of British Columbia, Canada. Her research focuses on online searching, human information behavior and task-based approaches to search, including exploratory search (Wildemuth & Freund, 2012) and semantic navigation (Kopak, Freund & O'Brien, 2011). Further information on her research is available at: http://faculty.arts.ubc.ca/lfreund. On this panel, she will present methods and measures that have been used to assess reading comprehension and learning and consider some of the challenges in applying these approaches to studies of searching. Her brief presentation will draw upon experience gained while conducting a user study comparing comprehension outcomes from different online reading environments, in which the assessment was based on Walter Kintsch's (1998) Construction-Integration model of comprehension.

Kevyn Collins-Thompson is Associate Professor in the School of Information at the University of Michigan, with an affiliate appointment in the Department of Electrical Engineering and Computer Science. Before joining Michigan in September 2013, he spent five years as a research scientist at Microsoft Research. His work combines information retrieval, machine learning, and natural language processing, particularly to enable effective learning-related scenarios for search. His goal of developing search engines that help people learn has been a continuing theme throughout his research career, leading to pioneering work in areas such as automated readability assessment using machine learning (Collins-Thompson and Callan, 2005), specialized search engines for intelligent language tutors (Collins-Thompson and Callan, 2004), Web search engines that personalize by reading level (Collins-Thompson et al., 2011), and search engines that support effective topic exploration (Raman, Bennett, Collins-Thompson, 2013). His panel presentation will focus on methods and evaluation for learning-related tasks in large-scale, online scenarios like Web search.

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