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Guest editorial

Solving information-based problems: Evaluating sources and information

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**Abstract**

The focus of this special section is on the processes involved when solving information-based problems. Solving these problems requires from people that they are able to define the information problem, search and select usable and reliable sources and information and synthesise information into a coherent body of knowledge. An important aspect throughout the whole search process is the critical evaluation of sources and information. Evaluation processes are of particular importance when searching information on the Internet, because of the masses of information, and the open publication principle of the Internet. The articles in the present special section take different perspectives in studying the evaluation processes. Influencing factors such as students' domain specific prior knowledge, metatextual knowledge, and students' epistemic beliefs are addressed.

*Keywords:* Information problem solving, Multiple document comprehension, Hypertext learning, Web search

## 1. Introduction

In 2009, the Danish ministry of education was reportedly the first official council in the world to grant high-school students full access to the Internet during their final exams (Dansk Undervisnings Ministeriet, 2009). What has been tested in an exceptional pilot project with 14 schools across the country is planned to be implemented nationwide from 2011 onwards. According to the ministry, the rationale underlying this bold step is that everyday learning in the 21st century is already dominated by the use of various electronic sources. Only during school and university examinations, the use of external resources of knowledge is usually unwanted and even punished.

Indeed, in our information society deriving meaning from a multitude of heterogeneous sources has become a common way for individuals to tackle tasks and problems that require (expert) knowledge to be solved (cf. Rouet et al., 2009). This happens in institutionalized learning settings such as schools or universities, where individuals use the Internet to complete their assignments (be it on their own initiative at home or as part of the curriculum) (Dinet, Marquet, & Nissen, 2003; Kolikant, 2009). In addition, the task of making meaning out of multiple sources can also be found in more informal learning contexts, that is, outside of schools. The wide-spread search for health-related information on the Internet in the run-up of medical decision-making is just one (very prominent) example of this phenomenon (Fox, 2006). Here, individuals also need to form a basic understanding of the medical concepts at hand, to make an informed, that is, knowledge-based decision (Stadtler & Bromme, 2008).

Research on the interaction with electronic information repositories has long been rooted in the information retrieval approach and consequently empirical research in this area focused on clarifying the process of searching and locating relatively simple pieces of information (Gatten, 2004; Hill, 1999; Hölscher & Strube, 2000; Marchionini, 1995; Sutcliffe & Ennis, 1998; Zins, 2000). With the rising use of electronic information resources in everyday life and for educational purposes, however, researchers devoted more attention on unravelling the process of establishing meaning out of complex documents that learners will encounter when accessing the World Wide Web to learn out about a specific topic. This more psychological approach of getting grip of the cognitive processes involved when making meaning out of complex documents provides the framework for the articles in the present special section. Furthermore, a special emphasis is put on a critical reflection of methodological approaches used to investigate processes of information problem solving.

## 2. What matters in solving information-based problems?

To describe the nature of authentic, everyday problem-solving in more depth, Brand-Gruwel, Wopereis, and Vermetten (2005) introduced the notion of Information Problem Solving (IPS; see, also, Eisenberg & Berkowitz, 1990; Moore, 1995). The authors contend that IPS can be decomposed into five constituent skills. These skills, which are meant to be executed in iterative cycles are: (a) Define information problem; (b) Search information; (c) Scan information; (d) Elaborate information; and (e) Organize and present information (for a comprehensive description of the model, see Brand-Gruwel et al., 2005). Inherent to the model is the assumption that due to the growing specialization in all scientific areas there is a large number of (everyday) problems, for which knowledge is necessary that exceeds what an individual might

know as part of his or her general education (Bromme, 2005; Bromme, Kienhues, & Porsch, 2009). Consequently, an individual needs to access external sources of knowledge for solving these problems. It should be noted that this is a crucial extension of traditional notions of problem solving. These have been based on the tacit assumption that a problem solver needs to have at his/her disposal both cognitive skills and pertinent topic knowledge in order to succeed (Newell & Simon, 1972). Moreover, it was assumed that both components have to be available to the problem solver from the outset of the problem-solving process to be successful. The use of external sources to gather information critical to the problem solution, which is at the core of IPS, has not been part of the processes under investigation.

As a consequence, an important aspect throughout the whole search process is the critical evaluation of sources and information in terms of relevance and reliability. Evaluation processes receive particular relevance when searching information on the Internet, where traditional gatekeepers of credibility, such as editors are missing. Especially when it comes to health information provisions, it has frequently been reported that documents contain flawed or strongly biased information (Fox, 2006). Unfortunately, past research has shown that students of all ages (primary, secondary and higher education) regularly encounter difficulties when evaluating Web information in terms of relevance and reliability (Brand-Gruwel, Wopereis, & Walraven, 2009; MaKinster, Beghetto, & Plucker, 2002; Walraven, Brand-Gruwel, & Boshuizen 2008). When evaluating results and sources secondary educational students judge sources and information using superficial criteria, such as amount of information and the language in which the information is written to select information (Walraven et al., 2008). However, with respect to the methodologies used in research on individuals' evaluation skills, Gerjets, Kammerer, and Werner (**YEAR: PROVIDED BY ELSEVIER**) raise the issue of how spontaneous these evaluations reported in the literature really are. Using thinking-aloud methodology in combination with gaze data they were able to demonstrate that explicit evaluation instructions resulted in more utterances of quality-related evaluation criteria and in an increased attention focus on user ratings displayed on Web pages.

It should be noted that relevance evaluations often must be made on the basis of surface information, such as keywords highlighted in a search engine output, entries in a navigational menu or a text's headings. To scan documents for relevant text passages fast and effectively, individuals have to possess metatextual knowledge, that is, knowledge about the functions of structural features of a text, such as headings, paragraphs or hyperlinks (Rouet & Eme, 2002; Rouet, Ros, Goumi, Macedo-Rouet, and Dinet, **YEAR: PROVIDED BY ELSEVIER**). In this context, Rouet et al. (**YEAR: PROVIDED BY ELSEVIER**) studied primary and secondary school students' ability to use semantic and more superficial typographical cues of relevance when making relevance judgments in a simulated Web-search task. A central finding is that fifth and seventh grade students' choices were strongly influenced by superficial relevance cues, such as matching keywords and typographical emphasis, as opposed to the global meaning of the short text passage. The influence of superficial cues decreased in older students. These results are in line with previous findings on studies on the longitudinal trajectories of metatextual knowledge development, which reveal an increase in metatextual knowledge primarily during secondary education (Rouet & Eme, 2002).

Past research revealed that the process of information evaluation is also influenced by students' domain-specific prior knowledge (Makinster et al., 2002). Studies by Britt and Aglinskas (2002), Lundeberg (1987), Rouet, Britt, Mason, and

Perfetti (1996) and Wineburg (1991) revealed that, compared to novices, experts attend to source information to a greater deal when evaluating documents than novices. For instance, law professors in a study by Lundeberg (1987) paid much attention to the date and the name of the judge involved, when reading legal cases. This kind of source information was often ignored by novices in the legal domain. Furthermore, Rouet et al. (1996) found that undergraduates mostly used characteristics of the content to evaluate documents, while graduate students in history mainly based their evaluations on document type. Also, Nievelstein (2009) found that first and third year law students experienced difficulties using sources like law books and court judgments and lack the conceptual and ontological knowledge to interpret the information found in the source. Although third year students are more experienced in solving law problems, their lack of domain knowledge still prevents them from solving the problem. It seems that domain knowledge put students into a better position to evaluate the content of a particular website. It enables students to quickly recognize what aspects are relevant to the task requirements. So, domain experts seem to be in advantage, because they can easily link prior knowledge to task requirements and to information found on the Web. Building on this strand of research, Bråten, Strømsø, and Salmerón (**YEAR: PROVIDED BY ELSEVIER**) investigated how undergraduate students judge the trustworthiness of different information sources on a timely issue, namely climate change. Results revealed that readers with low topic knowledge were more likely to trust less trustworthy sources and failed to differentiate between relevant and irrelevant criteria when required to judge the trustworthiness of sources.

Another individual difference factor that has been found influential in evaluating online sources is epistemic beliefs, namely the beliefs an individual holds about the nature of knowledge and how one comes to know (Hofer & Pintrich, 2002, Mason & Boldrin, 2008; Mason, Boldrin, & Ariasi, in press). Kienhues, Stadtler, & Bromme (**YEAR: PROVIDED BY ELSEVIER**) extend current findings on the interplay between epistemic beliefs and IPS on the Internet. They raise the question whether dealing with controversial scientific information during IPS can alter epistemic beliefs towards adopting a less positivistic stance. Their study follows a recent investigation of Kienhues, Bromme and Stahl (2008), in which they were able to demonstrate that challenging epistemic beliefs through refutational epistemic instruction resulted in noticeable changes in domain-specific epistemic beliefs. Thus, being confronted with controversial information in authentic problem-solving tasks might serve to accomplish an important educational goal: getting a more differentiated insight into the nature of knowing and the conditions of its knowledge production in our modern information societies. In what follows, we shall describe the articles of the present special section in more detail.

### **3. The present special section**

The present special section examined the processes involved when evaluating sources and information for solving information-based problems. The use of criteria, the impact of epistemic beliefs and of prior domain knowledge is studied, but also the use of different cues for studying hypertext will be addressed. The four articles focus on the process of evaluating sources and information in different ways and using different methodological approaches.

The article of Bråten et al. (**YEAR: PROVIDED BY ELSEVIER**) focuses on how students judge the trustworthiness of multiple, partly conflicting, information

sources dealing with climate change, as well as the criteria they use to judge their trustworthiness. In particular, they address students' judgement of trustworthiness and emphasise the variety of criteria used to evaluate the different information sources. With respect to the IPS process, this study can be positioned in the part in which one is scanning and processing information and during these processes evaluates the trustworthiness of the information found. The students did not define the search questions, and also did not search for sources. The task (imagine you have to write a brief report to other students about how climate change might influence life on Earth and what were the causes of climate change) was given and the students received seven printed texts (popular science text, newspaper text, public information text, text from a textbook in nature studies, etc.). Students did not actually write the report. Results revealed that participants, 128 undergraduate students, judged information from textbook and official documents to be more trustworthy than information from newspapers and a commercial agent. Moreover, Bråten et al. (**YEAR: PROVIDED BY ELSEVIER**) showed that readers low in topic knowledge were more likely to trust less trustworthy sources and failed to differentiate between relevant and irrelevant criteria when judging the trustworthiness of sources. The impact of prior knowledge on students' evaluation behaviour is in this study confirmed, but important is to put this finding into perspective. The students in this study were asked to judge the trustworthiness of given texts and a difference between students with high and low prior knowledge level was found. But, what happens if students are working on a school assignment? Do these students with high prior knowledge in this setting also show more sophisticated evaluation behaviour? In other words, do students also judge the trustworthiness spontaneously?

The article by Kienhues et al. (**YEAR: PROVIDED BY ELSEVIER**) investigates whether learning from controversial scientific medical information online influences different levels of epistemic beliefs. Furthermore, it examines the effect of dealing with conflicting evidence on health decision making as well as the relation between epistemic beliefs and decision making. The students, 100 university students (predominantly in the humanities), worked on an assignment, in which a search question was defined: Could you advise a fictional friend to take medicine to lower her high cholesterol? To accomplish this task, participants had 15 pre-selected websites at their disposal. This means that students did not search freely on the Web for sources and information. One condition got websites with consistent information and one condition got websites with conflicting information. Changes in epistemic beliefs of these groups were compared with a control group that also answered the epistemic beliefs measures twice, however without conducting a Web search in-between. For topic-specific epistemic beliefs, results showed that those studying conflicting information believed to a lesser degree in the possibility of finding the one best solution for the task and stated that different opinions on the question at hand may all be (partly) right. In contrast, the consistency group held a more positivistic view after Web search. On a medicine-specific level, both groups who conducted a Web search changed towards a more advanced view. From this study it can be concluded that dealing with information of different degrees of consistency on the WWW evokes qualitatively different epistemic beliefs in students, even in a short-term intervention.

The article by Rouet et al. (**YEAR: PROVIDED BY ELSEVIER**) describes two experiments. The experiments investigated primary and secondary school students' strategies when selecting items from Web-like menus. It was hypothesized that students' selections in Web-like menus depend on their perception and

integration of multiple relevance cues. More specifically, students should be able to disentangle superficial cues (e.g., typography) from deeper, semantic cues. This study focuses on the search process and how students use visual or semantic cues when selecting sources from a Web-like menu given a certain search topic (e.g., the construction of medieval castles). Also in this study the students did not define the search question. Concerning the search process, they did not determine the search terms for searching; the menu was given, using predefined search terms. Results revealed that 5th- and 7th-grade students tended to rely on lexical and typographical cues when assigning relevance, with relatively less consideration for deeper semantic cues. The relative impact of surface cues decreased throughout secondary education, and was negligible by the 12th grade. Furthermore, it was found that reading a short text about the search topic prior to selecting menu items improved good readers' selection of semantically relevant items at the 5th and 7th grades. These results show the importance of teaching students to make use of deeper, semantic cues when selecting items from a Web menu. The authors discuss the results in terms of the development of executive control skills in children and younger adolescents, and implications for the use of Web-based tasks in instructional settings are considered.

The article by Gerjets et al. (**YEAR: PROVIDED BY ELSEVIER**) aims at studying students' spontaneous evaluation behaviour when searching the Web for information and also aims at discussing methodological approaches commonly used to investigate evaluation processes during Web search. Based on a review of relevant studies they analyze methodological shortcomings of the research methods applied and make several suggestions for possible improvements. The study focuses on the scanning and processing phases of the IPS process. The students did not search on the Web, but got a predefined search engine result page. Also the search task was well described (to achieve an informed decision, for a fictitious overweight friend, between low fat and low carb diets with regard to which of the two diet methods better promotes a healthy and long lasting weight loss). To compare spontaneous with instructed evaluation behaviour eye-tracking data was used in combination with thinking-aloud protocols. Implicit cognitive processes that do not show up in users' utterances could be fine grained. Results revealed that users, 30 university students, in the instructed evaluation condition differed in their thinking-aloud behaviour from users in the spontaneous evaluation condition in that they showed more credibility-related utterances when they inspected the result pages. Furthermore, evaluation instructions increased the rate of utterances with respect to quality-related criteria like up-to-datedness, design, and credibility. Gaze data showed that evaluation instructions increased searchers' attention for quality-related information like user ratings, and influenced the results of their information problem solving.

The special section will be closed with two commentaries. Wopereis and Van Merriënboer (**YEAR: PROVIDED BY ELSEVIER**) and Goldman (**YEAR: PROVIDED BY ELSEVIER**) give their critical reflections on main issues and open questions, as well as stimulating thoughts for a future research agenda.

### 3. Conclusion

Especially in the last two decades, researchers from different fields, such as information retrieval, educational and cognitive psychology have tried to model and theoretically reconstruct learning with complex electronic knowledge resources. In the very beginning, this research was led by the hope that learning from electronic sources bears the potential to increase learner motivation, flexibility of mental

representations and an orientation towards comprehending complex problems instead of accumulating simple facts.

However, we are now able to say that learning from multiple information sources is anything but straightforward. Just making information sources available is not sufficient to foster learning or to solve information-based problems. To succeed, learners are rather required to apply numerous cognitive skills, from searching and evaluating, to integrating information. The articles in the present special section aim to contribute to our understanding of the cognitive processes involved in the meaning making out of complex, electronic documents in reaction to an information-based problem.

From the articles in the present special section it can be concluded that solving information-based problems is indeed a demanding cognitive endeavour. Constructing meaning from multiple sources and especially when those sources are made up of hypertext and include conflicting information involves complex cognitive processes, such as the evaluation of sources and information. The studies in the present special section reveal that these processes are influenced by students' knowledge and beliefs. Prior domain knowledge does have an impact on students' evaluation behaviour in a sense that students with low prior knowledge do trust less trustworthy sources and do not differentiate between relevant and irrelevant criteria when judging the trustworthiness of sources. Metatextual knowledge or knowledge about the functions of structural features of a text, such as headings, paragraphs or hyperlinks is of importance. Students tend to rely on lexical and typographical cues when assigning relevance, with relatively less consideration for deeper semantic cues. Also epistemic beliefs are related to how people evaluate information and sources. In this sense, the materials retrieved in Web search function as a mediator. If conflicting information is found, this has an impact on people's confidence that they found an appropriate answer.

However, the relation between prior knowledge, metatextual knowledge and epistemic beliefs when solving information-based problems in different settings is not studied. In future research, fine-grained experiments should focus on unravelling the IPS processes involved in different circumstances and go into the interrelations of the influencing factors. Research methods used to gain insight into cognitive processes have become more sophisticated and methods such as eye tracking and cued retrospective reporting (using eye-movements as cue) have proven to be successful research methods besides the often used thinking aloud method (Van Gog & Scheiter, 2010; Van Gog, Paas, Van Merriënboer & Witte, 2006).

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