

**Students' conceptions of information retrieval:
Implications for the design of learning environments**

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Abstract

In order to design information retrieval (IR) learning environments and instruction, it is important to explore learners' conceptions of the domain to be examined. This study addresses the issue by investigating students' conceptions of IR know-how and its implications for designing learning environments for information retrieval. The focus of this study is the integration of research on IR instruction and constructivist learning environments. The study of conceptions and constructivist instructional design is a novel approach in library and information science. The results present five qualitatively different conceptions of IR know-how, and explore the connections between these conceptions and learning style, enrollment type and major subject. The implications for learning environment design are further discussed.

1 Introduction

Web-mediated information services and sources have made information retrieval (IR) a commonplace activity. Furthermore, in educational settings the discussion of information literacy has become increasingly prominent. The reason for this growing interest is twofold: first, the rise of the importance of information searching in curriculum and, second, the availability of electronic information sources and search tools. Different models for applying information literacy education in curricula have been reviewed (Bawden, 2001) as well as pedagogical solutions to information literacy education have been evaluated (Webber & Johnston, 2000).

The importance of networked information services and information literacy has made IR know-how an important part of lifelong learners' knowledge base. IR instruction is routinely organized on different levels, for example, by schools, universities, libraries, online vendors and consultants. In addition to the commonality of IR skills, they are a key area of expertise for information professionals. A wide variety of textbooks about the basics and principles of searching have been published (e.g., Harter, 1986; Hersh, 1996; Lancaster & Warner, 1993; Large, Tedd, & Hartley, 1999). The educational material covers four main areas, focusing on presenting (1) the context of information retrieval as a part of information seeking activities, (2) the basic principles of information retrieval systems, (3) general search strategies applicable in all ordinary retrieval settings, and (4) specific search strategies for particular retrieval settings and information sources. The main goal of instruction is to

develop learners' practical capability to perform any search task that appears in the task situation successfully.

Likewise, "hands-on-keyboard" classroom exercises are a common method for teaching and studying practical searching skills. Operational search systems and databases or their training versions are typically used. The advantage of using operational systems is that the learner gets a realistic sense of the particular system used. The individual also learns the typical operations of a retrieval system, and appropriate ways to formulate queries. There are very few studies on learning and instruction of information retrieval in the traditional context but it is easy for professional IR educators to identify some shortcomings of this approach. One of the shortcomings is the fact that educators and instructional designers seldom pay attention to learners' conceptions of the domain to be learned and its effect on learning experiences and outcomes.

This article describes, however, first year university students' conceptions of IR know-how. Looking at the conceptions is part of a larger research effort in order to develop and evaluate different modules of an IR learning environment. The study has four subtasks:

1. Description of Information Retrieval Game (also called Query Performance Analyzer), one module of the learning environment, and pilot evaluation of instructional use of this software application. (see Halttunen and Sormunen (2000); Sormunen, Halttunen, and Keskustalo (2002); and Sormunen et al. (1998).

2. Study on students' prior conceptions of IR and their implications for the design of learning environments. Findings of this investigation are reported in the current article.
3. Investigation on students' learning experiences and performance in two learning environments (Halttunen, submitted).
4. Evaluation of learning outcomes (In preparation).

Conceptions of IR know-how form a background for learning IR and the knowledge of them raises ideas for building modules of IR learning environment. The specific research questions are:

- What kinds of conceptions do students have about IR know-how?
- Are there observable groups of conceptions that can be identified?
- Are the students putting emphasis on certain phases of searching process?
- Are there differences in conceptions related to student status (IS major/ IS minor), learning style or the academic discipline that they are studying as their major subject?
- What possible implications do conceptions of IR know-how have on the design of learning environments?

There is no previous research focusing on conceptions in relation to learning and teaching IR know-how although connections between these domains are evident.

1.1 Prior knowledge and conceptions of phenomena

Prior knowledge, prior learning and conceptions of the domain to be learned, as well as conceptions of learning assignments, are important in constructing

new knowledge. Educational psychologists discuss schemata as mental structures for organizing information and representing knowledge and schemata which are theoretical knowledge structures that contain information, facts, principles, and the relationships among them. Schemata are discussed in terms of prior knowledge. Furthermore schema-based representations of experience, including perceptions of task demands and task performance are discussed as mental models (Anderson, 1977; Driscoll, 1994).

Prior knowledge and prior learning have been discussed in information studies research from a couple of perspectives. In research, focusing on professional online searchers' prior knowledge of subject domain or information retrieval has been described as a factor that affects searching time, search strategies, and query formulation (see, e.g., Fenichel, 1981). Prior knowledge and learning have also been studied in connection with relevance assessments (Barry, 1994; Janes, 1994), navigation and browsing hypertext (McDonald & Stevenson, 1998; Small & Grabowski, 1992), and self reliant searchers of the Web (Lazonder, Biemans, & Wopereis, 2000; Palmquist & Kim, 2000). These studies bring new insight to expert and novice searchers' cognitive behavior, but they do not reveal actors' conceptions of the phenomenon and its effect on their behavior.

The present research discusses conceptions through phenomenographic approach, which is designed to discover and describe the qualitatively different ways in which phenomena that students encounter are experienced, conceptualized, and understood (Marton, 1981). The analysis primarily looks

for qualitative differences in the way in which the students experience the phenomenon of IR know-how.

Previously conceptions have been studied, especially in relation with students' learning outcomes. A central finding of early phenomenographic research was that ways of experiencing assignments explained the differences in students' learning outcomes. Investigations on the relationship between the outcome and process of learning demonstrated that the two are intrinsically related. This research led to the distinction between holistic and atomistic and between deep and surface approaches to learning tasks (Dall'Alba, 1996; Marton, 1988; Marton & Säljö, 1976a; 1976b).

Phenomenographic approach has been used to explore student conceptions of domain to be studied (e.g., gravitation). This procedure has taken place in information gathering for adaptive tutoring systems (Laurillard, 1992) and the evaluation of learning outcomes and experiences in computer supported learning environments (Jones & Asensio, 2001).

In information studies, the phenomenographic approach has been used to investigate different conceptions in information literacy and their effect on information-seeking behavior (Bruce, 1997; Webber & Johnston, 2000) as well as the relation between information seeking and learning outcomes (Limberg, 1999). Conceptions of thesauri and their effect on online searching have also been studied (Klaus, 1999).

1.2 Learning environments and constructivism

Discussion of learning environments has brought together, at least implicitly, information seeking and retrieving activities in connection with views of information literacy. Learning environments have been defined in many ways, but the definition of Wilson (1996) gathers together essentials of constructivist learning environment: "*a place where learners may work together and support each other as they use a variety of tools and information sources in their guided pursuit of learning goals and problem-solving activities*". Perkins (1991) suggests that all learning environments, including traditional classrooms, include the following key components or functions: (1) *information sources*; (2) *symbol pads*, that is, tools to manipulate symbols and language; (3) *phenomenaria* as area for presenting, observing and manipulating phenomena; (4) *construction kits* such as math-manipulation or multimedia authoring software; and (5) *task managers* such as teachers, tutors and co-learners.

If Wilson (1996) and Perkins (1991) focus on different elements and processes in their discussion of learning environments, Collins, Brown, and Newman (1989) have concentrated on different instructional methods to be applied in an learning environment. They have presented the characteristics of an ideal learning environment. They have constructed the model through the cognitive apprenticeship model and situated learning. The framework describes four dimensions that constitute any learning environment: *content, method, sequence, and sociology*. Relevant to each of these dimensions is a set of characteristics that should be considered in constructing or evaluating

learning environments. For example, characteristics of method include *modeling, coaching, scaffolding and fading, articulation, reflection, and exploration.*

Coaching consists of observing students while they carry out a task and offering hints, feedback, scaffolding, modeling, reminders, and new tasks aimed at bringing their performance closer to expert performance.

Scaffolding refers to different kinds of supports that learners receive in their interaction with teachers, tutors and different kinds of tools within a learning environment.

The current conceptions of learning emphasize learning as a constructive process, which is tightly interrelated with prior knowledge structures. The constructivist view of learning can be summarized as follows: First, learning is a process of knowledge construction, not of knowledge recording or absorption. Second, learning is knowledge-dependent, people use current knowledge to construct new knowledge. Third, learning is highly tuned to the situation in which it takes place. Effective learning depends on the intentions, self-monitoring, elaborations, and representational constructions of the individual learner (Resnick, 1989).

2 Methods and data collection

A total of 120 students attended the course called "Introduction to Information Retrieval" (6 ECTS credits) at the Department of Information Studies of the University of Tampere during the fall semester 2000. Multiple datasets for

research project on design and evaluation of IR learning environment were gathered during the course: (1) short essay describing students conceptions of IR in the beginning of the course; (2) a questionnaire on conceptions; (3) a learning style inventory; (4) search logs in tutored exercises; (5) a short essay describing students conceptions of IR in the end of the course; (6) empathy-based stories describing students subjective learning experiences; and (7) course feedback.

In the present article relevant datasets 1-3 are used to answer research questions put forward in chapter one. Datasets 4-7 are to be used in other studies in the research project. Overview of research design and datasets is presented in Figure 1.

>Insert Figure 1. about here<

There is a complete collection of different datasets (1-7) from 57 participants (Table 1), of which 28 had Information Studies as a major subject (IS Major) and 29 students as a minor subject (IS Minor). Forty-two students were female and 15 male. According to Kolb's (1976, 1984) learning style inventory students emphasize following learning modes and styles: (1) concrete experience (10); (2) reflective observation (26); (3) abstract conceptualization (16); and (4) active experimentation (5). Out of many test assessing learning modes, styles and orientations Learning Style Inventory (LSI) by David Kolb was selected for two reasons. First, LSI-test has been used before in IS/IR settings (see for example Logan, 1990; Logan & Woefl, 1986; Saracevic &

Kantor, 1988). Second, test is based on experimental learning approach, which is suitable for interactive IR instruction.

>Insert Table 1. about here<

The data were gathered by the author who attended lectures and exercises on a regular basis. The lecturer and the researcher introduced data collection procedures and the aims of the research to the participants. Data collection was planned as an integral part of the course, not just as an artificial extra part. For example, the learning style inventory was analyzed on site and the students, therefore, had the opportunity to understand their own learning styles. Writing an essay on prior conceptions of IR in the beginning of the course served as an orientation, and it created an interest in the topic at hand. In this way, writing assignments were used as advance organizers and as a means to bridge and activate prior knowledge and conceptions of the new area of study (Corkill, 1992 ; Derry, 1984; Mayer, 1979.) The approach of this research is reminiscent of qualitative action research, which is commonly used in education (Bogdan & Biklen, 1982).

Students wrote essays (45 minutes) and filled out the questionnaire (15 minutes) as in-class assignment in the very beginning of the first lecture. Data gathering preceded any formal instruction in this course that might have influenced the findings. Instruction to essay writing was put forward as: "Write an essay-type text, in which you present your own description of information retrieval know-how. You can approach the topic by identifying different kinds of skills, knowledge, elements etc. which, in your mind,

belong to IR know-how". After writing the essay, students filled out the questionnaire (Appendix 1) which presents visual analogue scales (VAS) of the different kinds of conceptions of IR. They presented their views from three different perspectives: (1) what the important aspects of IR know-how are; (2) what their present knowledge about these aspects is; and finally, (3) what they expected the important aspects of IR to be in the course they were attending. VAS was used because we did not want to categorize the levels of importance in advance, but direct students to form their own categorizations. Learning style inventory was filled out and analyzed in the second lecture of the course.

The present study is a combination of the phenomenographic approach based on student essays on IR know-how and an analysis of prior conceptions based on a questionnaire. The analysis of the essays is based on a grounded theory approach, which is common due to the fact that phenomenography is clearly an approach, not a solid method, in phase of an analysis (Richardson, 1999).

We collected all the statements concerning conceptions of IR know-how from each essay and compared the statements between and within essays. In the analysis we were primarily looking for qualitative differences in the way in which students experienced the phenomenon of IR know-how. The evolving pattern of differences and similarities was then captured in a set of categories of description. The categories of description were again applied to the data, which resulted in modification of categories. Examples of wording are presented in Table 2.

3 Results

The results of the study are presented in the following manner. First, a qualitative analysis of essays describing students' conceptions. Second, the analysis of questionnaire data. Third, second order analysis based on the first results.

3.1 Conceptions of IR know-how based on qualitative data

The analysis of conceptions of information retrieval revealed 12 main categories of interpretations of IR know-how (see Table 2). The most cited elements were knowledge of information sources, IR methods, relevance assessment, computer skills, problem formulation, and intermediary functions. The students' conceptions were highly scattered among the different phases of information searching process. The most frequently mentioned element "knowledge about information sources" was mentioned by one-half of the students. The searching process was often described as process with different phases, such as the identification of information need, the selection of information sources and tools, the construction of query, and the evaluation of search results. The search process covers temporal phases starting from the formulation of information need and ending to evaluation of search results. The searching is done with a computerized IR systems. Idea of temporal search process with consecutive phases is based on practical experience and data in present research. The search process has been presented in several text-books and articles describing IR activities. (see, for example, Harter, 1986; Hersh, 1996; Large et al., 1999; Marchionini, Dwiggins,

Katz, & Lin, 1993.) Descriptions of the students' conceptions follow the temporal phases of a search process. In addition to the search process, participants elaborated conceptions of self-reliant searchers and information intermediaries as well as the effect of computer skills and linguistic talent to IR know-how. These background conceptions are reported after the search process. (The presentation in Table 2 also follows the above-mentioned order.)

>Insert Table 2 about here<

3.1.2 Information needs, prior knowledge, and problem formulation

In the first phase of a search process an information problem is raised. Prior knowledge about the search topic was mentioned nine times in the essays. It was mostly referred to as all-round education or multidisciplinary education. Some students drew a comparison between prior knowledge and searching skills. The ability to formulate an information problem into a search problem was one of the main themes of students' conceptions. On the one hand, students' focused on identifying basic concepts of search topics. Problem formulation was described with expressions such as:

- "The first task of information retrieval is question/problem formulation (different perspectives etc)" [003pc : 4-4]; and

- "The first step in IR know-how is to define, limit and formulate the information need as exactly as possible: what one wants to know" [039pc : 4-6].

On the other hand, problem formulation was discussed in contexts such as usability, form, topicality, and the abstraction level of needed information. IS major students and those with learning style "abstract conceptualization" found problem formulation to be a more important part in IR know-how than others.

Problem formulation is an important, but, in many cases, neglected part in IR instruction. The formulation of meaningful search and learning tasks has especially been considered in context of information literacy instruction (Webber & Johnston, 2000). One could argue that in the current state of the development of IR techniques, emphasis should be directed from query construction to analyzing search tasks, information needs and problem formulation. Problem formulation, as well as query construction, needs scaffolding in educational setting. Scaffolding is a technique to support learners to work and move from the actual level to the potential level that can occur with guidance or collaboration from a more competent person. The background of the concept is Vygotsky's zone of proximal development (Vygotsky, 1978). Winnips and McLoughlin (2001) have presented different techniques for scaffolding, such as providing examples both on processes and products; asking questions; giving hints and cues; and giving away parts of solutions of learning assignments. These ideas can be used to scaffold the

problem formulation phase of the information searching process as well as query construction.

3.1.3 Information sources

The participants' conceptions of information sources varied widely. Most of them treated information sources on a general level: "Well, how do you choose the appropriate information source for your information need. Appropriate? Well, that is exactly IR know-how" [005pc : 11-11].

Most of the students who elaborated information sources further offered a very holistic view about them:

- "... you have to know different kinds of organizations that support information seeking, like libraries, archives, information services etc. In addition to those you can use human information sources, network or literature [022pc : 2-3].
- " You should be able to pick up relevant and reliable information from enormous amounts of information presented in mass media and networks" [043pc : 3-3].

In addition the level of sources varies from open media environments to bibliographical databases of specific domains. Furthermore, conceptions of interactions with these sources form a continuum from strict, planned

intentional information searching in a database to unintentional information encountering in the media landscape.

Students' wide variety of conceptions of information sources could be exploited in a learning environment by presenting collaborative overall views and conceptual mappings of different information sources. The idea of presenting and learning global skills before local skills discussed by Collins, Brown, and Newman (1989) is a suitable frame of reference in this context. This means that if the learners have a clear conceptual model of the overall activity it both helps to make sense of the pieces that they are carrying out.

3.1.4 Information retrieval methods

The students discussed IR methods on four different levels. At the most general level the participants pointed out the importance of the appropriate usage of search tools. Tools like Internet search engines and bibliographic databases were mentioned. In this case the emphasis was on tool functions rather than in information content as in the case of information sources. The overlap between conceptions on tools and sources was only 15 %.

Eighteen participants mentioned the need for understanding the functionality of different search tools, but they were unable to discuss those in more detail: "... you need knowledge of how a search tool works and how to make different kind of searches... [017pc : 11-11].

More detailed discussions by 18 participants concentrated on query formulation and search term selection as part of IR know-how. These were described with expressions such as:

- "An important part of IR know-how is appropriate formulation of search terms and statements in connection with right search operators" [013pc : 3-3]; and
- "When huge amounts of information are available you have to filter it. Knowledge of using different kinds of search statements to filter information is part of IR know-how [048pc : 5-6].

Major IS students placed more emphasis on search terms and statements and tool aspects than minor IS students did. On the other hand, minor IS students did not ignore searching methods, rather they discussed them more generally.

Nevertheless, information storage was discussed rarely in the essays. Conceptions of storage fall in three categories. First, the majority of these essays stress the importance of knowing the principles behind information organization in certain retrieval tools or information sources. This was expressed in essays in wording like: "... one should know the basic structure of retrieval tools on which slightly differing search services are based on ... [038pc : 4-4].

Second, a couple of participants put forward the idea that in order to be a successful searcher one should also have knowledge and skills to store

documents in databases and offer access mechanisms for them. Third, information storage was seldom seen in the context of storing search results and requests for later use.

Students' conceptions of IR methods were highly scattered, pointing in different directions. Because of this fuzzy picture, students probably focus on these topics in the IR learning environment. The danger of this approach is the concentration on searching techniques and query construction while neglecting problem formulation and the analysis of information sources used. Passion for achieving good results is present at least in systems providing performance feedback as Halttunen and Sormunen (2000) have demonstrated. The discussion of global and local skills as well as different scaffolding techniques is important in this context.

3.1.5 Assessing relevance, information sources and tools

Conceptions of relevance assessment were described in three qualitatively different ways. First, students talked about relevance assessment as an overall approach to interpret search results and the information found. This was done in the context of information need, and it was highly affected by the notion of usefulness of information to task completion. Like in the instance: " It requires knowledge and skills to evaluate relevance of the found documents - so it is part of IR know-how" [006pc : 4-4].

Second, participants made distinction between "correct or false" information. Their approach was more like judging the trustworthiness of information found. Third, participants put forward the idea of the evaluation of information sources and tools. Little attention was paid to the evaluation of information sources and tools.

Assessing relevance and the evaluation of search tools is an important module in an IR learning environment. In traditional hands-on exercises in the operational IR systems a lot of time and cognitive effort is devoted to the assessment of search results. In some systems, like former Dialog Ontap ERIC Trainer (Markey & Atherton, 1978) and IR Game (Halttunen & Sormunen, 2000; Sormunen, Halttunen, & Keskustalo, 2002; Sormunen et al., 1998) predefined relevance data are used to present performance feedback to the searcher. This approach makes it easy to demonstrate the basic principles of IR systems and methods. On the other hand, it has its shortcomings, such as ideas of "correct answers and solutions," ideas of exhaustive and ideal query formulations. This is somehow contradictory to an approach often mentioned in discussion about constructive learning and learning environments, where learning tasks and assignments should offer multiple perspectives, global skills before local, and real world cases.

One way to approach the problem of assessing relevance in IR instruction could be based on recent discussion of relevance in the context of information seeking and evaluation of IR systems. Borlund (2000a, & 2000b) has presented an evaluation package of interactive IR systems (IIR systems). She used simulated work tasks in order to provide real-world context to test-persons in

a controlled experiment and proved that these simulated work tasks or "cover stories" could be used in evaluation of IIR systems. Cover stories or cases with solid background could be used in IR learning environments. This approach is reminiscent of ideas of anchored instruction by Cognition and Technology Group at Vanderbilt (1992). Using simulated work tasks and anchored instruction which offer complex enough real-world problems calls after multilevel relevance data as well as an analysis of multiple aspects of relevance such as document type, size, date and, in newspaper articles, the placing in news event timeline.

3.1.6 Search process and information use

The students' conceptions of IR know-how are highly centered around the beginning of the search process. There were only occasional references to the final parts of the process. This may be due to the fact that only three participants explicitly constructed a process description in their essay. These process descriptions were also richer and more structured in their conceptions presenting seven themes whereas the average was four and a half.

Five participants discussed information use from slightly different perspectives. One conception was the refinement of the information found. This process was related to relevance assessments, but it had more aspects of creating and communicating new knowledge to others. Some students even hesitated to present this view like in the expression: "Information use know-how - this goes little bit aside" [044pc : 9-9].

It is important to elaborate the process approach presented by a few students further. It seems to be evident that those students had adopted a clear conceptual model of overall IR activity. It would be possible to follow their path in the IR learning environment through further research in order to demonstrate the consequences of their model in different activities like IR skills and learning experiences and outcomes.

3.1.7 Individual differences and intermediaries or self-reliant searchers

Some participants clearly pointed out the individual characteristics of good information seekers. It seems that these characteristics are connected to some sort of information professionalism because only students studying Information Studies as a minor chose these features describing them as relating to "other persons" than themselves: "It seems that [IR expertise] stands for a certain kind of personality if you want to be a professional" [056pc : 10-10].

Because IR has become much a more commonplace activity than earlier and, at the same time, the occupational field of IR experts has spread out, the intermediary function of the information professional has diminished.

The distinction between professional intermediaries and self-reliant searchers is an important module of information retrieval learning environment.

Modeling experts' performance and cognitive apprenticeship are recommended regularly as suitable instructional methods. In the case of IR modeling and apprenticeship have to be looked in broad context: how to cope

with different stakeholders in the field of information needs, seeking, retrieval, and use. This context can be expressed as a question: What is the expert practice that forms the frame of reference for the didactic use of modeling and apprenticeship in a learning environment? Modeling involves an expert carrying out a task so that students can observe and build a conceptual model of processes that are required to accomplish the task. In cognitive domains, modeling requires the externalization of cognitive processes and activities, especially heuristic and control processes by which experts make use of basic conceptual and procedural knowledge (Collins, Brown, & Newman, 1989).

3.1.8 Computer skills and linguistic talent

IS major students most often described computer skills as essential skills for IR. Although some participants even defined IR as a computer and network skill, the majority of students saw computer skills as a prior condition for using electronic information sources. The distinction between electronic and printed sources heavily affected students' conception of the importance of computer skills. These students saw the understanding of "the world of publications" as important part of IR know-how.

Linguistic talent was mentioned only in four essays. Linguistic skills were presented in two ways. First, as an ability to figure out, define and formulate appropriate keywords. This included the understanding of the inflection of words. Second, as knowledge of foreign languages.

A conceptual model of the world of publications and different kinds of texts with linguistic expressions is one area in a learning environment. This approach calls for an understanding of the multiplicity of document types in multiple languages and texts from different kinds of genres as well.

In a process of designing IR learning environments one should not overlook different kinds of search aids which are present in naturalistic searching environments such as dictionaries, thesauri, reference books, colleagues and so forth.

3.1.9 Differences in conception by student status, domain and learning style

There were some differences in conceptions of IR know-how related to students' status, major study domain and learning style (Table 3).

>Insert table 3 here<

Students majoring in information studies place slightly greater emphasis on the portions of information needs, sources, and methods as well as assessment in their conceptions. They also stress the importance of computer skills. Minor IS students pay attention more to information storage, access, and use of information found as well as the understanding of information production and publishing. Only minor IS students presented the process approach to IR know-how. Those studying in the master's degree program in networked information services placed emphasis on information needs, sources, and

assessment. Interestingly, they put forward ideas of intermediary functions and individual differences in connection with IR know-how.

>Insert Table 4 here<

The students' major area of study had quite the same distribution of conceptions as presented earlier by student status (see Table 4). This is due to fact that major IS students are present in the social science category. Science students are largely computer science students so it is clear that they do not place emphasis on computing skills. They point to knowledge of information sources, methods, access, and use as well as assessment, but do not take into account the analysis of information needs as a central area of IR know-how as do the students of social science and the humanities. Students of the humanities put forward the importance of information storage and knowledge of information production and publishing. They also emphasized IR-methods and sources of information.

>Insert Table 5 here<

Learning styles generate interesting groups in conceptions of IR know-how (see Table 5). Students with concrete experience computer skills and IR-

methods as important areas of know-how followed by sources, storage, and assessment. Most of the students belong to the learning mode reflective observation. They see IR know-how mainly as the knowledge of information needs analysis, methods, and assessment. Students with a learning style that leans towards abstract conceptualization stress the importance of information sources and needs as well as methods and computer skills. The group of students with an active experimentation learning mode is the smallest of all groups. Thus, this group does not indicate remarkable differences between themes, but all major themes of IR know-how are well present in this group.

3.2 Questionnaire results of different elements of IR know-how

After writing essays, the participants filled out a questionnaire that presented visual analogue scales (VAS) of different kind of elements of IR know-how (see Appendix 1). Elements mentioned in the questionnaire were (1) computer skills; (2) language skills; (3) knowledge of information sources; (4) search process; and, (5) the evaluation of the information found. Students answered the questionnaire from three different viewpoints: what are important aspects of IR know-how; what is their present knowledge about these aspects; and, what do they expect to be important aspects of IR in this course. VAS results are based on measurement of the point in axis (0 - 6 cm). The statistical significance was tested with Kruskal-Wallis one-way analysis of variance by ranks, which is suitable test for deciding whether differences among samples signify genuine population differences in small independent samples based on ordinal data (Siegel & Castellan 1988, pp. 206-216). There was no

statistically significant difference between learning styles, enrollment types, major subject and elements of IR know-how. Figure 3 presents an overview of questionnaire results.

>Insert Figure 3 about here<

Students consider the management of the search process as the most important aspect of IR know-how, although in the essays the process approach was rarely mentioned. Knowledge of information sources is considered important both in overall views as well as in expectations of the course. Students evaluate their own know-how of information sources to be lowest of the different aspects.

Students seem to have a different approach to computer skills and the importance of language in IR than to sources, process and, evaluation. They think that it is best to have current know-how in linguistic aspects of IR and do not have high expectations of the course from this perspective. The overall importance of computer skills seems to have higher rank than evaluation of information found. Computer and linguistic skills are probably regarded as background skills in contrast with other elements, which are probably linked more directly with IR activities.

There are some interesting correlations of questionnaire results and learning style, student status (IS major, IS minor, master's degree program in network services) and the domain of students' major subject (social sciences, natural sciences, humanities, master's degree program). The learning style defined as

natural does not seem to have any remarkable effect on the expressed importance of different elements of IR know-how. Participants with learning style leaning toward *active experimentation* have put linguistic aspects to highest rank. Learning style is, thus, probably more correlated with learning outcomes and performance in learning environment. These aspects can be examined in forthcoming studies within the current project on information retrieval learning environments.

>Insert Figure 4 about here<

Enrollment types, IS major or IS minor, strongly correlate with one another regarding the expectations. Only students in master's degree program expect less of computer skills (see Figure 4). Expectations are formed in relation to learners' conception of one's own understanding and know-how in different areas of domain. If student thinks that she is a skillful computer specialist, she probably do not expect development in computer skills in an introductory course on information retrieval, rather expectations lie in more specialized topics. Expectations of the course and learning environment should be taken into account in a similar way as conceptions of domain. They have an effect on the overall orientation to the learning situation.

>Insert Figure 5 about here<

While there are individual differences, in general, students rate themselves as stronger in linguistic and computer skills and weakest in knowledge of information sources, there are differences also between student groups (see Figure 5). Natural science students assess their current know-how highest in computer skills and linguistic talent, and lowest in evaluation. Humanities students assess themselves as strong in languages and weakest in knowledge of information sources. The situation with social science students is identical to humanities students. Students in the master's degree program are very self-reliant. They assess their current know-how strong on computer skills, process and evaluation. They consider themselves weakest in knowledge of information sources.

3.3 Second order analysis

Based on the analysis of short essays written in the beginning of the introductory course of IR the following categories of interpretations can be formed: process identifiers; source identifiers; searchers; problem formulators; and, assessors. Categories are based on the co-occurrence of themes of IR know-how in the temporal phases of search process (see Figure 6 and Table 6). The bar in Figure 6 representing each group identifies what phases of the search process were present in their conceptions. The density of shading describes the percentage of participants mentioning certain phase in their conceptions. (100%=black ; 99-67%=dark grey ; 66-34%=medium grey ; 33-1%= light grey ; 0%=white)

>Insert Figure 6 about here<

>Insert Table 6 about here<

The group labeled as *process identifiers* extended the search process most completely. Nevertheless, their conceptions do not cover all aspects of assessment, access and use as much as some other groups. Participants seldom explicitly mentioned a process approach as pointed out earlier. In any case, three students noted that this conception covered most parts of the process. *Source identifiers* did not pay attention to IR methods at all. They focused on identifying relevant information sources. In addition, they also stressed information needs as well as access and use.

Searchers concentrated heavily on IR-methods and the evaluation of search results along with minor emphasis on other elements of IR know-how.

Problem formulators were distinguished from other groups by concentrating heavily on the beginning and end phases of the search process. They paid attention to the analysis of information needs and, to some extent, to the evaluation of information found, but they totally neglected information sources and retrieval methods. Lastly, there were participants that concentrated on the assessment phase of process. These *assessors* also covered information sources as well access and use.

4 Discussion

Research on the instruction of IR is disjointed, lacking a solid background in both information studies and educational research. The following three orientations can be found in the literature. First, the education of professionals in information and library science. This meager research has analyzed, for example, the amount and share of IR instruction in curricula, the presence and integration of IR instruction in different courses and differences between the covered domains and instructional methods and materials. (see, e.g. Hsieh-Yee, 1997; Still, 1993). Second, there is a large amount of literature of user education in libraries. Bibliographic instruction covers some aspects of IR know-how. The research has concentrated mainly on teaching methods and the implementation of computer-assisted tutorials as well as on the coverage of courses. (see, e.g. Bren, Hillemann, & Topp, 1998; Holman, 2000; Sinn, 1998; Tomaiuolo, 1998). Third, there are a few studies on the instruction of IR in other domains than information studies such as: journalism (Wien, 2000) and education (see, e.g. Hill & Hannafin, 1997; Land & Greene, 2000; Lazonder, 2000; Oliver, 1996; Oliver & Oliver, 1997). This rising trend of IR instruction, especially in the field of education, calls for solid research on IR instruction and learning environments.

The results of the current study suggest that the learners' conceptions of IR know-how cover a broad spectrum of IR activities. Analysis of short essays revealed 12 categories of description, namely: information needs; information sources; IR-methods; Information storage; Assessment of information and

information systems; Access and use of information; Computer skills; Linguistic talent; Intermediary functions; Individual differences; Publishing and information production, and finally Process knowledge of information searching.

These different conceptions are scattered over the different phases of the search process. In the second-order analysis descriptions of IR know-how were grouped based on their co-occurrence in the temporal phases of search process. Students fall in to five qualitatively different groups, namely: Process identifiers; Source identifiers; searchers; problem formulators; and, assessors.

Students were paying attention especially to the beginning phases of search process. There were no significant differences in conceptions and learning modes and styles. Student status (IS major, IS minor) effected conceptions in some degree. IS major students emphasized information needs analysis and IR methods more and IS minor students paid emphasis on assessment, access and use, and knowledge on publishing and information production.

In order to develop meaningful learning environments it is important to pay attention to these conceptions. The learners' conceptions of the domain to be studied place high expectations on learning environments and instruction.

Based on the current research these requirements are:

- The realization of the effect of qualitatively different conceptions and methods for analyzing those conceptions;

- Learners construct and interpret information presented in a learning environment in relation to their conceptions, for example the phase in search timeline like "identify source"; and
- Problems and difficulties in learning and instruction that arise from different conceptions must be treated in the design of learning environments.

Studying conceptions of IR know-how is also important in order to evaluate learning outcomes and learning experiences in the subsequent phases of the current project. The conceptions of the domain to be learned form the baseline for evaluation.

The current view of learning as constructive (Glaser, 1991; Resnick, 1987), situated (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991) and collaborative (Barab & Duffy, 2000; Teasley & Rochelle, 1993) can offer some solutions to designing constructive information retrieval learning environments. These suggestions are based on results of the present study on conceptions of IR know-how in interplay with research on constructive learning environments.

Implications for design of IR learning environments can be summarized in design principles such as:

- Activate and take into account conceptions of domain to be learned;
- Use a situated and authentic approach;
- Cover the whole domain through a process approach and scaffolds;

- Use anchored instruction, simulated work tasks or authentic tasks; and
- Avoid the passion for gaming.

Activate and take into account conceptions of the domain to be learned. The commonality of using IR systems is creating different experiences and conceptions of IR. Sharing and articulating one's conceptions form a base for instruction. A great variety of conceptions calls for overviews, process approaches and scaffolds.

Use a situated and authentic approach. Results of the present study show that learners of IR have a very scattered conception of the domain to be learned. To overcome this shortcoming, learning environments should be based on authentic activities. Honebein, Duffy, and Fishman (1993) specify authentic activities and context as the elements of constructive learning environments. The authenticity of the learning activity refers to the activity of the learner in the learning environment relative to the environment in which acquired knowledge and skills will be used. Authentic activities exist in both global and local entities. The global defines the entire task, while local refers to sub-tasks. The global task environment, including the purpose for undertaking the global task, gives meaning to each of the local tasks. In the present context these ideas stress the importance of the emphasis on forming sparse conceptions of IR know-how to dense ones by applying a process approach and making information searching activities meaningful both in global and local tasks. The assessment of the information found and information sources and tools makes better sense when working on complex enough real-world problems. There are naturally good opportunities to offer authentic and

situated tasks in IR learning environments. With some effort it is possible to provide real or simulated real-like information problems with relevant tools to resolve them. Sharing tasks, knowledge and tools are dimensions of learning that should be put forward in IR instruction. By situating information-seeking and retrieving tasks (Brown, Collins & Duguid, 1989; Lave & Wenger, 1991; Wilson & Myers, 2000), real-world problems offer possibilities to activate situated cognition and avoid learning being inert and nontransferable to other situations (Mandl, Gruber, & Renkl, 1996).

Cover the whole domain through a process approach and scaffolds. In addition to global authentic activities, different kind of scaffolding or support can be offered to learners in order to form their sparse conceptions of IR into dense ones. There are applicable types of scaffolding in IR instruction. First, giving away parts of solutions of information retrieval task. Second, providing overviews and examples of processes. Third, modeling expert performance (Winnips, Collins, & Moonen, 2000; Winnips & McLoughlin, 2001).

Use anchored instruction, simulated work tasks or authentic tasks. Anchored instruction is an instructional approach developed by the Cognition and Technology Group at Vanderbilt (1990 ; 1992). It is strongly associated with situated learning and constructive learning environments. The major goal of anchored instruction is to overcome the problem of inert knowledge by teaching problem solving skills and independent thinking. The basis of the approach is to build semantically rich anchors, background stories in different media (video, sound, and text) that illustrate important problem solving situations. These anchors create a macrocontext that provides a common

ground for experts as well as teachers and students from diverse backgrounds, to communicate in ways that build collective understanding. An anchored instruction learning environment permits sustained exploration by students and teachers. Furthermore, it enables them to understand the kinds of problems and opportunities that experts encounter and the knowledge that experts use as tools.

Avoid the passion for gaming. Based on their conceptions of IR know-how learners can place emphasis on searching without analyzing the process and functions of the search tools. This passion for gaming, which was one of the observations in the pilot study of the IR Game, one module of designed IR learning environment (Halttunen & Sormunen, 2000), could be decreased by scaffolding problem formulation and assessment of process and relevance of information found as well as the articulation of one's plans, actions and results. Articulation includes any method of getting students to articulate their knowledge, reasoning, or problem solving processes in a domain. Researchers have identified several methods of articulation. First, inquiry teaching is a strategy of questioning students to lead them to articulate and refine prototheories. Second, teachers might encourage students to articulate their thoughts as they carry out their problem solving. Third, they might assume the role of critic or monitor in cooperative activities and thereby lead students to formulate and articulate their knowledge of problem-solving and control processes. Insight into other perspectives arises when students try to explain the idea to others and they begin to see the idea from other perspectives. Reflection refers to the students looking back over what they did and analyzing their performance, or comparing it to the expert's or their

peers' performances. It is partly a meta-cognitive activity, since the object of reflection is often a cognitive learning process. Reflection encourages the students to think about their processes from the point of view of how they might be different and what changes would lead to improved performance (Collins, Brown, & Newman, 1989).

5 Conclusions

The main contributions of the present study are threefold. First, the overall approach to learning and instruction of IR know-how is based on the ideas developed in a constructive learning environment research. This is a novel and important approach to IR because the commonality of IR tools available for information seeking purposes calls for an integrated, task based approach in instruction on these tools and methods. IR skills remain inert if they are not utilized in constructive learning environments.

Second, methods and approaches to study learner's conceptions of the domain to be learned have seldom been used in information studies. Studying qualitatively different ways of understanding the phenomena to be studied and learned forms the basis for successful design of learning environments. The commonality of IR activities forms people's conceptions of IR in much wider scale than earlier and therefore it is important to study these conceptions in an educational setting.

The third contribution is the categorization of learners' conceptions of the IR know-how into five categories which are based on the phases in the search

process timeline with the measurement of the density of their conceptions, such as the number of phases covered in their conceptions. The current study also offers methods and measures to be applied in the design of learning environments and instruction. The effect of student learning style or status as majoring in information studies or studying IS as minor subject did not reveal major differences between different student groups, all though they are useful to place into discussion with qualitatively different ways to understand IR know-how in instructional situations.

The findings of the study set requirements for designing learning environments for IR and form a baseline for evaluation of learning outcomes and experiences in experimental IR learning environments. Further phases in the present research project will show whether there are connections between conceptions and learning outcomes both at the operational level (searching skills) and conceptually (the conception of domain). It will also be possible to analyze experiences with the data gathered in this research effort, and how different designs of the learning environment affect both learning outcomes and subjective learning experiences. In this context, at least part of the requirements set for a learning environment are operationalized and evaluated.

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Appendix 1.

Orientating questionnaire in the Introduction to information retrieval course

(Translated from Finnish)

Purpose of this questionnaire is provide tools to analyze your learning and learning goals. Mark in every section (1-3) a cross in visual scale to the point, which best describes your conception of the element. Mark also in every section two most important elements by numbers 1 = the most important and 2 = the second important element in the space at the end of the scale ().

Example:

Theme X	unimportant	_____X_____	very important ()
Theme Y	unimportant	_____X_____	very important (2)
Theme Z	unimportant	_____X_____	very important (1)

Section 1. How important is the know-how of following elements in information searching

Computer skills unimportant _____ very important ()

Linguistic know-how,
expression, knowledge on
languages unimportant _____ very important ()

Knowledge of information
sources, databases and
publications unimportant _____ very important ()

Knowledge of search
process: topic analysis,
selection of search terms and
databases etc. unimportant _____ very important ()

Evaluation of search process
and results unimportant _____ very important ()

Section 2. How do you evaluate your own know-how of elements in present moment?

Computer skills unskillful _____ skillful ()

[Same elements as in section 1]

Section 3. How important you regard following elements in this class. What do you want to learn most?

Computer skills unimportant _____ very important ()

[Same elements as in section 1]

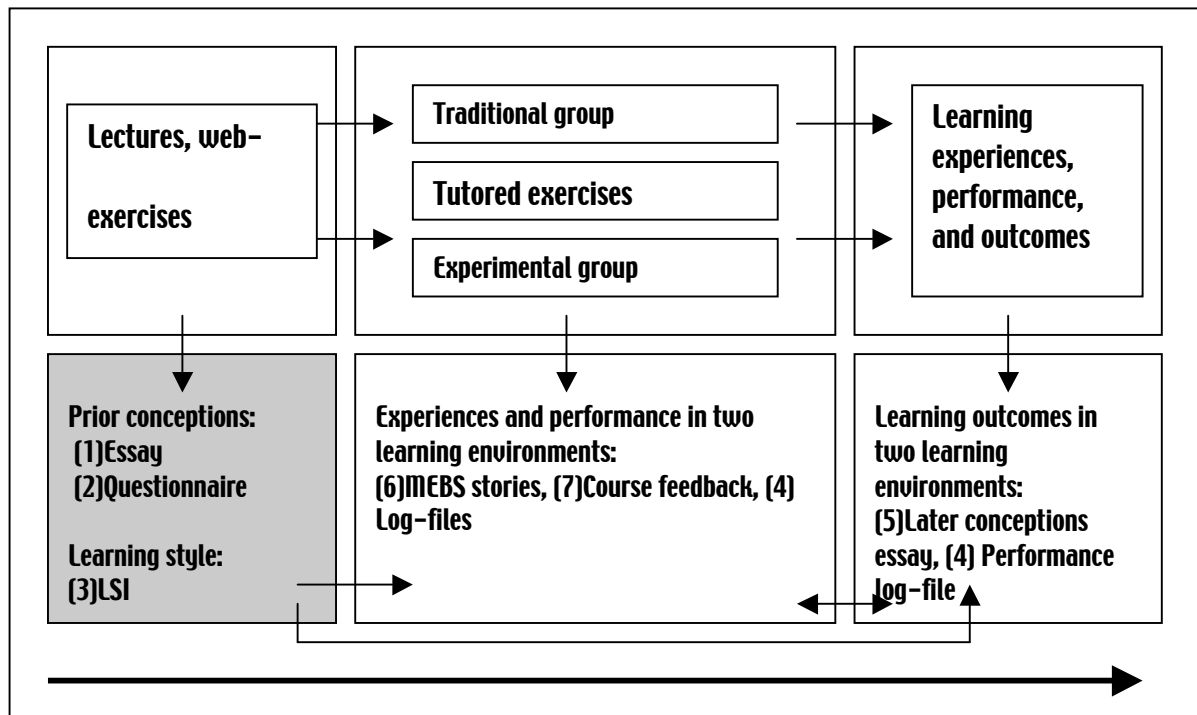


Figure 1. Research design

<i>Learning style</i>	<i>IS Major #</i>	<i>IS Minor #</i>	<i>Total #</i>
Concrete experience	4	6	10
Reflective observation	14	12	26
Abstract conceptualization	6	10	16
Active experimentation	4	1	5
Total	28	29	

TABLE 1. Participants of the study by learning style and student status.

<i>Conception</i>	<i>Students (n=57)</i>	<i>%</i>	<i>Senten-ces (n=450)</i>	<i>%</i>	<i>Examples of wording</i>
Information needs	29	51	57	13	problem formulation, topic
Information sources	31	54	73	16	databases, libraries, catalogs
IR methods	31	54	56	12	query, operators, truncation
Information storage	17	30	25	6	indexing, db's structure
Assessment	28	49	53	12	relevance, correct, reliable
Access and use	14	25	19	4	availability, presentation
Computer skills	22	39	43	10	computer, software, net
Linguistic talent	4	7	5	1	expressions, words, language
Intermediaries	14	25	18	4	professionals, librarians
Individual differences	8	14	16	4	precise, creative, logic
Publishing	6	11	14	3	publications, publishers
Process	3	5	3	1	search process, phases

Table 2. Students' conceptions of IR know-how

<i>Conception</i>	<i>IS Major</i>		<i>IS Minor</i>		<i>Masters</i>	
	n=28	%	n=21	%	n=8	%
Information needs	17	61	7	33	5	63
Information sources	15	54	11	52	5	63
IR-methods	17	61	11	52	3	38
Information storage	8	29	8	38	1	13
Assessment	14	50	10	48	4	50
Access and use	5	18	7	33	2	25
Computer Skills	14	50	5	24	3	38
Linguistic talent	2	7	1	5	1	13
Intermediaries	9	32	2	10	3	38
Individual differences	1	4	3	14	4	50
Publishing	0	0	6	29	0	0
Process	0	0	3	14	0	0

Table 3. Students conceptions of IR know-how, related to student status (IS major, IS minor, master's program in networked information services)

<i>Conception</i>	<i>Social sciences</i>		<i>Sciences</i>		<i>Humanities</i>	
	n=31	%	n=6	%	n=12	%
Information needs	18	58	2	33	4	33
Information sources	17	55	4	67	5	42
IR-methods	18	58	4	67	6	50
Information storage	9	29	1	17	6	50
Assessment	15	48	6	100	3	25
Access and use	6	19	4	67	2	17
Computer skills	15	48	1	17	3	25
Linguistic talent	2	6	0	0	1	8
Intermediaries	10	32	0	0	1	8
Individual differences	2	6	1	17	1	8
Publishing	0	0	1	17	5	42
Process	1	3	1	17	1	8

Table 4. Students conceptions of IR know-how, related to students major domain area of study, excluding students in masters programme

<i>Conception</i>	<i>Concrete experience</i>		<i>Reflective observation</i>		<i>Abstract conceptualization</i>		<i>Active experimentation</i>	
	n=10	%	n=26	%	n=16	%	n=5	%
Information needs	1	10	13	50	10	63	5	100
Information sources	4	40	11	42	12	75	4	80
IR-methods	6	60	14	54	8	50	3	60
Information storage	4	40	5	19	4	25	4	80
Assessment	4	40	14	54	6	38	4	80
Access and use	1	10	8	31	4	25	1	20
Computer skills	7	70	7	27	7	44	1	20
Linguistic talent	0	0	2	8	2	13	0	0
Intermediaries	2	20	8	31	3	19	1	20
Individual differences	2	20	3	12	3	19	0	0
Publishing	1	10	3	12	2	13	0	0
Process	1	10	2	8	0	0	0	0

Table 5. Students conceptions of IR know-how, related to learning styles

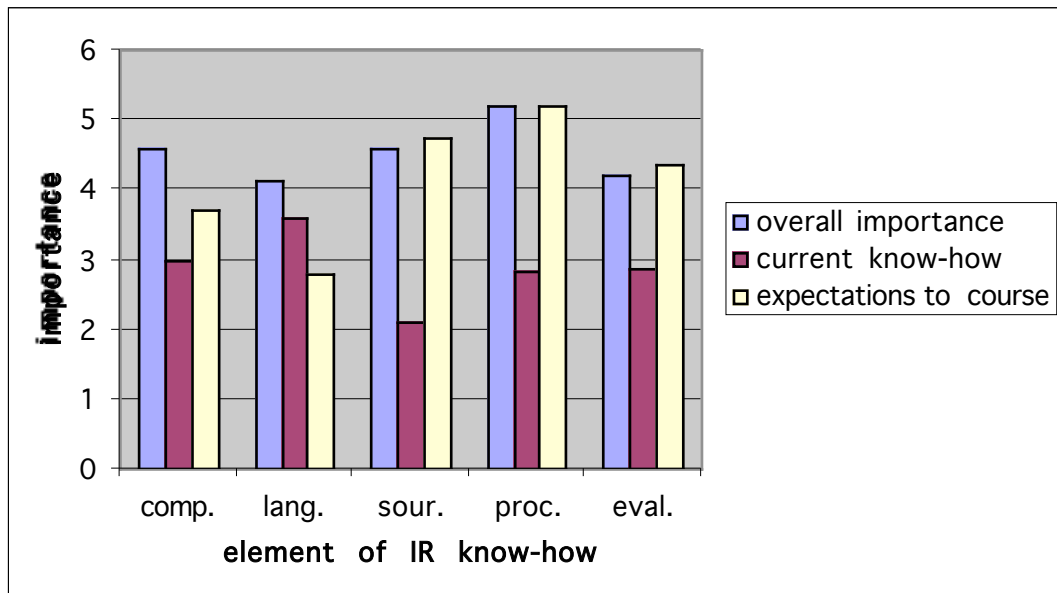


Figure 3. Students' expressed importance of different elements of IR know-how

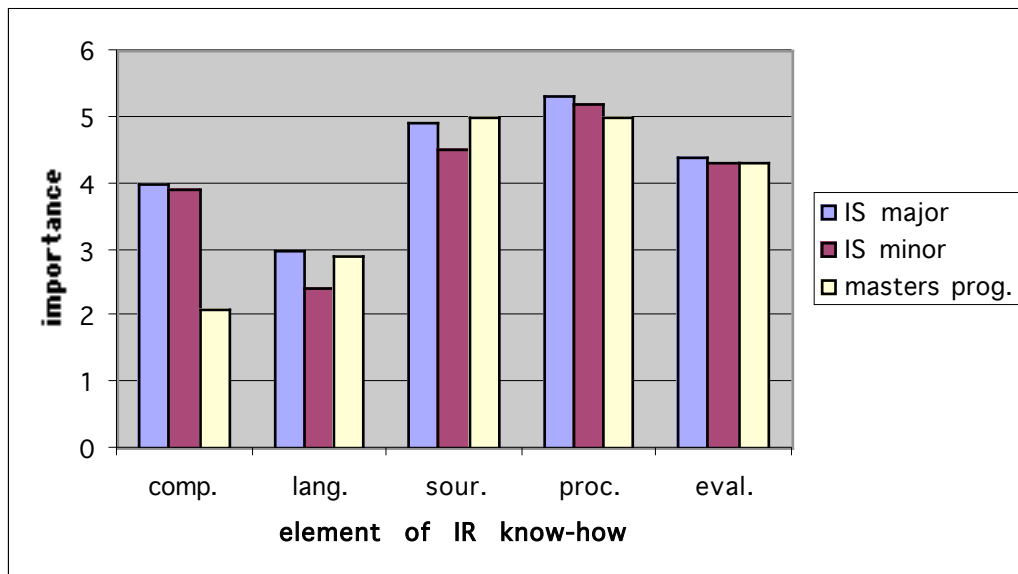


Figure 4. Expectations to the course by different student groups

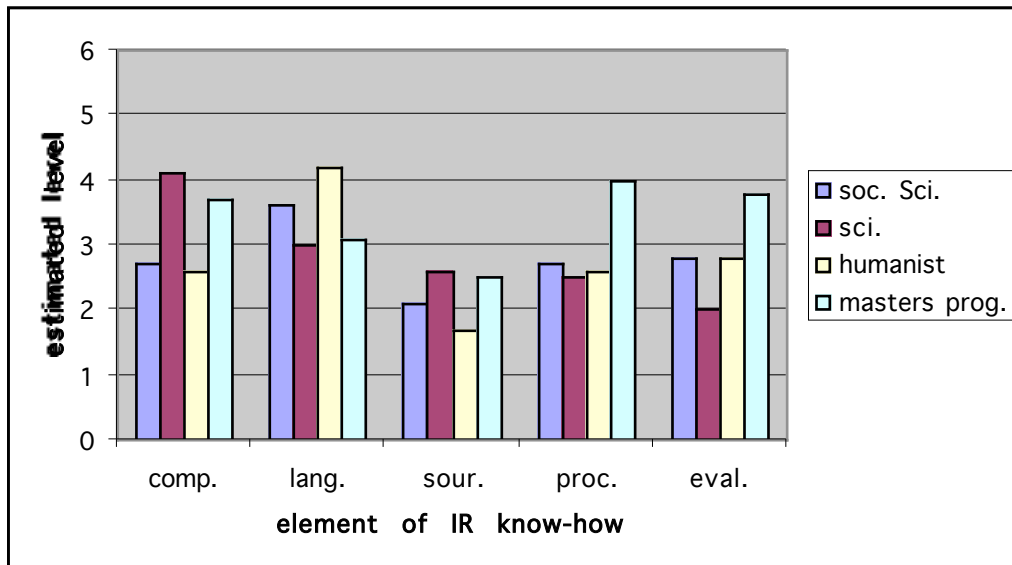


Figure 5. Current know-how by students majoring in different domains

Type	Phase	Info Need	Info Sources	IR Met hods	Info Storage	Assess ment	Access and use
Process identifiers		Black	Black	Black	Grey	Grey	Grey
Source identifiers		Grey	Black	White	Grey	Grey	Grey
Searchers		Grey	Grey	Black	Grey	Grey	Grey
Problem formulators		Black	White	White	Grey	Grey	Grey
Assessors		Grey	Grey	White	Grey	Black	Grey

Figure 6. Phases of search process by groups

<i>Type</i>	<i>Phase</i>	<i>Info. need</i>		<i>Info. source</i>		<i>I R methods</i>		<i>Storage</i>		<i>Asses- sment</i>		<i>Access an use</i>	
		<i>#</i>	<i>%</i>	<i>#</i>	<i>%</i>	<i>#</i>	<i>%</i>	<i>#</i>	<i>%</i>	<i>#</i>	<i>%</i>	<i>#</i>	<i>%</i>
Proces identifiers		9	100	9	100	9	100	1	11	3	33	2	22
Source identifiers		4	36	11	100	0	0	2	18	3	27	3	27
Searchers		7	33	7	33	21	100	6	29	10	48	4	19
Problem formulators		6	100	0	0	0	0	2	33	3	50	1	17
Assessors		1	14	4	57	0	0	1	14	7	100	3	43

Table 6. Number of students' conceptions in each phase of search process