Students’ conceptions of information retrieval
Implications for the design of learning environments

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Abstract

To design information retrieval (IR) learning environments and instruction, it is important to explore learners’ conceptions of the domain to be examined. This article addresses the issue by investigating students’ conceptions of IR know-how and its implications for designing learning environments for IR. This study focuses on the integration of research on IR instruction and constructive learning environments. The study of conceptions and constructive instructional design is a novel approach in library and information science. The article presents five qualitatively different conceptions of IR know-how and explores the connections between these conceptions and learning style, enrollment type, and major subject. In addition, the implications for learning environment design are discussed.
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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) and 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, these skills 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: (1) the context of IR as a part of information-seeking activities, (2) the basic principles of IR 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 successfully any search task that appears in the task situation.

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 IR in the traditional context, but it is easy for professional IR educators to identify some shortcomings of this approach. One of the shortcomings is 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 first-year university students’ conceptions of IR know-how. Looking at these conceptions is part of a larger research effort to develop and evaluate different modules of an IR learning environment. The research project consists of four studies:

1. Description of the Information Retrieval Game software (also called “Query Performance Analyzer”), one module of the learning environment, and pilot evaluation of instructional use of the software game application (see Halttunen & Sormunen, 2000; Sormunen, Halttunen, & Keskustalo, 2002; and Sormunen et al., 1998)
2. Study on students’ prior conceptions of IR and its implications for the design of learning environments. The findings of this investigation are reported in the current article.
3. Investigation on students’ learning experiences and performance in two learning environments (Halttunen, 2003)

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

- What kinds of conceptions do students have about IR know-how?
- Are there observable groups of conceptions that can be identified?
- Do the students emphasize certain phases of the searching process?
- Are there differences in conceptions related to student status (information science major versus information science 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.

2. Prior knowledge and conceptions of phenomena

Prior knowledge, prior learning, and conceptions of the domain to be learned, and
conceptions of learning assignments, are important in constructing new knowledge. Educa-
tional psychologists discuss schemata as mental structures for organizing information and
representing knowledge and schemata that are theoretical knowledge structures containing
information, facts, principles, and the relationships among them. Schemata are discussed in
terms of prior knowledge. Furthermore schema-based representations of experience, includ-
ing 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, professional online searchers’ prior knowledge of subject
domain or IR 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 a 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, 1994). The analysis primarily explores qualitative differences in the way
in which the students experience the phenomenon of IR know-how.

Conceptions have been studied previously, especially in relation to students’ learning
outcomes. A central finding of early phenomenographic research was that ways of
experiencing assignments explained the differences in students’ learning outcomes. Investi-
gations 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;

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

3. Learning environments and constructivism

Discussion of learning environments has brought together, at least implicitly, information-seeking and IR activities with views of information literacy. Learning environments have been defined in many ways, but Wilson’s (1996, italics by author) definition gathered together essentials of a constructivist learning environment as “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) suggested that all learning environments, including traditional classrooms, include the following key components or functions: (1) information sources; (2) symbol pads (i.e., tools to manipulate symbols and language); (3) phenomenaria as areas 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 colearners.

Wilson (1996) and Perkins (1991) focused on different elements and processes in their discussion of learning environments. Collins, Brown, and Newman (1989), however, have concentrated on different instructional methods to be applied in a learning environment. They presented the characteristics of an ideal learning environment and constructed the model through the cognitive apprenticeship model and situated learning. The framework described 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 that 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; and 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).
4. Methods and data collection

A total of 120 students attended the course called ‘‘Introduction to Information Retrieval’’ (6 European Credit Transfer System (ECTS) credits) at the Department of Information Studies of the University of Tampere during the fall semester of 2000. Multiple datasets for research project on design and evaluation of IR learning environment were gathered during the course as follows: (1) a short essay describing students’ conceptions of IR at 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 at the end of the course, (6) empathy-based stories (HEBS) describing students’ subjective learning experiences, and (7) course feedback.

In the present article, datasets 1 through 3 are used to answer research questions put forward in chapter 1 of the present article (see gray area in Figure 1). Datasets 4 through 7 are to be used in other studies in the research project. An overview of research design and datasets is presented in Figure 1.

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 had information studies as a minor subject (IS minor). Forty-two students were women and there were 15 men. According to Kolb’s (1976, 1984) learning-style inventory (LSI), students demonstrated the following learning modes and styles: (1) concrete experience (10 students); (2) reflective observation (26 students); (3) abstract conceptualization (16 students); and (4) active experimentation (5 students). Of the many test-assessing learning modes, styles, and

Fig. 1. Research design. MEBS, method for empathy based stories.
orientations, Kolb’s LSI was selected for two reasons: first, the LSI test has been used before in information science/IR settings (see, e.g., Logan, 1990; Logan & Woefl, 1986; Saracevic & Kantor, 1988); second, the test is based on an experimental learning approach, which is suitable for interactive IR instruction.

The data were gathered by the author, who regularly attended lectures and exercises. The lecturer and the researcher introduced the data collection procedures and the aims of the research to the participants. Data collection was planned as an integral part of the course, not as an artificial extra component. For example, the LSI was analyzed on-site; the students, therefore, had the opportunity to understand their own learning styles. Writing an essay on prior conceptions of IR at the beginning of the course served as an orientation and created an interest in the topic at hand. In this way, writing assignments were used as advance organizers and 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 similar to 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 assignments at the beginning of the first lecture. Data gathering preceded any formal instruction in this course that might have influenced the findings. The instructions for essay writing were as follows: “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 (see Appendix), which presents visual analog scales (VASs) of the different conceptions of IR. They presented their views from three perspectives: (1) the important aspects of IR know-how, (2) their present knowledge about these aspects, and (3) their expectations regarding the important aspects of IR in their course. The VAS was used because the researcher did not want to categorize the levels of importance in advance but direct students to form their own categorizations. The LSI was filled out and analyzed in the second lecture of the course.

The present study combines 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 because phenomenography is clearly an approach, not a solid method, in phase of an analysis (Richardson, 1999).

The researcher collected all the statements concerning conceptions of IR know-how from each essay and compared the statements between and within essays. In the analysis, the researcher primarily was looking for qualitative differences in the way in which students

<table>
<thead>
<tr>
<th>Learning style</th>
<th>No. IS major</th>
<th>No. IS minor</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
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<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Reflective observation</td>
<td>14</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>Abstract conceptualization</td>
<td>6</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Active experimentation</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

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

5. Results

The results of the study are presented as follows. First is a qualitative analysis of essays describing students’ conceptions. Second is an analysis of questionnaire data. Third is a second-order analysis based on the results of the first analysis.

5.1. Conceptions of IR know-how based on qualitative data

The analysis of conceptions of IR 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 the 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 a query, and the evaluation of search results. The search process covered temporal phases, starting from the formulation of information need and ending with the evaluation of search results. The search was performed with computerized IR systems. The idea of a temporal search process with consecutive phases is based on practical experience and data in present research. Search processes have been discussed in several textbooks and articles describing IR activities (see, e.g., Harter, 1986; Hersh, 1996; Large et al., 1999; Marchionini, Dwiggins, 

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<table>
<thead>
<tr>
<th>Conception</th>
<th>Students</th>
<th>%</th>
<th>Sentences</th>
<th>%</th>
<th>Examples of wording</th>
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<td>12</td>
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<td>17</td>
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<td>Assessment</td>
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<td>53</td>
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<td>Access and use</td>
<td>14</td>
<td>25</td>
<td>19</td>
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<td>5</td>
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<td>4</td>
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<tr>
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<td>14</td>
<td>3</td>
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<tr>
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<td>5</td>
<td>3</td>
<td>1</td>
<td>Search process, phases</td>
</tr>
</tbody>
</table>
Katz, & Lin, 1993). Descriptions of the students’ conceptions followed the temporal phases of the search process. In addition to the search process, participants elaborated on 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 previously mentioned order.)

5.1.1. Information needs, prior knowledge, and problem formulation

In the first phase of the search process, an information problem was raised. Prior knowledge about the search topic was mentioned nine times in the essays. It was mostly referred to as all-around 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. Students focused on identifying basic concepts of search topics. Problem formulation was described with expressions such as the following:

The first task of information retrieval is question/problem formulation [different perspectives, etc.]. (student 3)

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. (student 39)

Problem formulation, however, 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 did others.

Problem formulation is an important but, in many cases, neglected part of 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, and query construction, needs scaffolding in an 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 (1978) zone of proximal development. Winnips and McLoughlin (2001) have presented different techniques for scaffolding, such as providing examples on processes and products, asking questions, providing 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 and query construction.

5.1.2. 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” (student 5).
Most of the students who elaborated information sources further offered a 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. (student 22)

You should be able to pick up relevant and reliable information from enormous amounts of information presented in mass media and networks. (student 43)

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’ various 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, as discussed by Collins et al. (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 helps to make sense of the pieces that they are carrying out.

5.1.3. IR methods

The students discussed IR methods on four levels. At the most general level, the participants pointed out the importance of the appropriate usage of search tools. Tools such as Internet search engines and bibliographic databases were mentioned. In this case, the emphasis was on tool functions rather than on information content, such 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: for example, “you need knowledge of how a search tool works and how to make different kind of searches” (student 17).

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

An important part of IR know-how is appropriate formulation of search terms and statements in connection with right search operators. (student 13)

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. (student 48)

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

Nevertheless, information storage was discussed rarely in the essays. Conceptions of storage fell into three categories. First, most essays stressed the importance of knowing the
principles behind information organization in certain retrieval tools or information sources. This was expressed in wording such as “one should know the basic structure of retrieval tools on which slightly differing search services are based on” (student 38). Second, a couple of participants offered the idea that, to be a successful searcher, one should also have the 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. Because of this fuzzy picture, students probably focused on these topics related to IR methods in the IR learning environment. The danger of this approach is that, by concentrating on search techniques and query construction, problem formulation and analysis of information sources are neglected. A passion for achieving good precision/recall-levels is present i.e. using artificial strategies to improve precision, such as the use of the not-operator to exclude irrelevant search terms and picking up very rare, meaningless terms from documents, at least in systems providing performance feedback, as demonstrated by Halttunen and Sormunen (2000). The discussion of global and local skills and different scaffolding techniques is important in this context.

5.1.4. 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. For example, one student stated, “It requires knowledge and skills to evaluate relevance of the found documents — so it is part of IR know-how” (student 6). Second, participants made distinctions 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, although 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 on operational IR systems, much time and cognitive effort is devoted to assessing search results. In some systems, such as the former Dialog Ontap ERIC Trainer (Markey & Atherton, 1978) and the Information Retrieval Game (Halttunen & Sormunen, 2000; Sormunen et al., 1998, 2002), 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; however, it has its shortcomings, such as ideas of “correct answers and solutions” and ideas of exhaustive and ideal query formulations. This approach contradicts an approach often mentioned in discussions about constructive learning and learning environments, where learning tasks and assignments should offer multiple perspectives, global before local skills, 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 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 similar to ideas of anchored instruction formulated by the Cognition and Technology Group at Vanderbilt (1992). Using simulated work tasks and anchored instruction that offer sufficiently complex, 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 of article in news event timeline.

5.1.5. Search process and information use

The students’ conceptions of IR know-how were highly centered around the beginning of the search process. There were only occasional references to the final parts of the process. This finding may be because only three participants explicitly constructed a process description in their essay. These process descriptions were also richer and more structured in their conceptions and represented seven themes, whereas the average number was four and one 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, such as was shown in the following statement: “Information use know-how — this goes little bit aside” (student 44).

It is important to elaborate further the process approach presented by a few students. It seems 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 to demonstrate the consequences of their model in different activities such as IR skills and learning experiences and outcomes.

5.1.6. 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” (student 56).

Because IR has become a much more commonplace activity 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 the IR 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 at in a 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 et al., 1989).

5.1.7. Computer skills and linguistic talent

Students who were IS majors most often described computer skills as essential skills for IR. Although some participants even defined IR as a computer and network skill, most 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 an important part of IR know-how.

Linguistic talent was mentioned in only four essays. Linguistic skills were described 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, linguistic skills were seen 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.

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

5.1.8. 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).

Students majoring in information studies placed slightly greater emphasis on information needs, sources, and methods and assessment in their conceptions. They also stressed the importance of computer skills. Students who were IS minors paid more attention to information storage, access, use of information found, and the understanding of information production and publishing. Only IS minors 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. In addition, they put forward ideas of intermediary functions and individual differences in connection with IR know-how.

The students’ major area of study had the same distribution of conceptions as shown in Table 3 (see Table 4), because IS majors were present in the social science category. Science students were largely those who studied computer science so they did not place emphasis on computer skills. They pointed to knowledge of information sources, methods, access, and use and assessment but did not take into account the analysis of information needs as a central area of IR know-how as did 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.

Learning styles generated wide differences in conceptions of IR know-how (see Table 5). Students who best learned through concrete experience listed computer skills and IR methods as important areas of know-how, followed by sources, storage, and assessment. Most students belonged to the learning style of reflective observation. They saw IR know-how mainly as the knowledge of information needs analysis, methods, and assessment. Students with a learning style that leaned toward abstract conceptualization stressed the importance of information sources, needs, and methods, and computer skills. The group of students whose learning style

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<thead>
<tr>
<th>Conception</th>
<th>IS major (n = 28)</th>
<th>IS minor (n = 21)</th>
<th>Masters (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information needs</td>
<td>17 61</td>
<td>7 33</td>
<td>5 63</td>
</tr>
<tr>
<td>Information sources</td>
<td>15 54</td>
<td>11 52</td>
<td>5 63</td>
</tr>
<tr>
<td>IR methods</td>
<td>17 61</td>
<td>11 52</td>
<td>3 38</td>
</tr>
<tr>
<td>Information storage</td>
<td>8 29</td>
<td>8 38</td>
<td>1 13</td>
</tr>
<tr>
<td>Assessment</td>
<td>14 50</td>
<td>10 48</td>
<td>4 50</td>
</tr>
<tr>
<td>Access and use</td>
<td>5 18</td>
<td>7 33</td>
<td>2 25</td>
</tr>
<tr>
<td>Computer skills</td>
<td>14 50</td>
<td>5 24</td>
<td>3 38</td>
</tr>
<tr>
<td>Linguistic talent</td>
<td>2 7</td>
<td>1 5</td>
<td>1 13</td>
</tr>
<tr>
<td>Intermediaries</td>
<td>9 32</td>
<td>2 10</td>
<td>3 38</td>
</tr>
<tr>
<td>Individual differences</td>
<td>1 4</td>
<td>3 14</td>
<td>4 50</td>
</tr>
<tr>
<td>Publishing</td>
<td>0 0</td>
<td>6 29</td>
<td>0 0</td>
</tr>
<tr>
<td>Process</td>
<td>0 0</td>
<td>3 14</td>
<td>0 0</td>
</tr>
</tbody>
</table>

<sup>a</sup> IS major, IS minor, or master’s program in networked information services.

Table 4
Students’ conceptions of IR know-how, related to students’ major area of study, excluding students in master’s program

<table>
<thead>
<tr>
<th>Conception</th>
<th>Social sciences (n = 31)</th>
<th>Sciences (n = 6)</th>
<th>Humanities (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information needs</td>
<td>18 58</td>
<td>2 33</td>
<td>4 33</td>
</tr>
<tr>
<td>Information sources</td>
<td>17 55</td>
<td>4 67</td>
<td>5 42</td>
</tr>
<tr>
<td>IR methods</td>
<td>18 58</td>
<td>4 67</td>
<td>6 50</td>
</tr>
<tr>
<td>Information storage</td>
<td>9 29</td>
<td>1 17</td>
<td>6 50</td>
</tr>
<tr>
<td>Assessment</td>
<td>15 48</td>
<td>6 100</td>
<td>3 25</td>
</tr>
<tr>
<td>Access and use</td>
<td>6 19</td>
<td>4 67</td>
<td>2 17</td>
</tr>
<tr>
<td>Computer skills</td>
<td>15 48</td>
<td>1 17</td>
<td>3 25</td>
</tr>
<tr>
<td>Linguistic talent</td>
<td>2 6</td>
<td>0 0</td>
<td>1 8</td>
</tr>
<tr>
<td>Intermediaries</td>
<td>10 32</td>
<td>0 0</td>
<td>1 8</td>
</tr>
<tr>
<td>Individual differences</td>
<td>2 6</td>
<td>1 17</td>
<td>1 8</td>
</tr>
<tr>
<td>Publishing</td>
<td>0 0</td>
<td>1 17</td>
<td>5 42</td>
</tr>
<tr>
<td>Process</td>
<td>1 3</td>
<td>1 17</td>
<td>1 8</td>
</tr>
</tbody>
</table>
best reflected active experimentation was the smallest of all groups. This group therefore did not demonstrate great differences between themes, but all major themes of IR know-how were well represented in this group.

5.2. Questionnaire results of different elements of IR know-how

After completing their essays, the participants filled out a questionnaire that presented VASs of different elements of IR know-how (see Appendix). Elements mentioned in the questionnaire were as follows: (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 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. The VAS results were based on measurement of the point in axis (0–6 cm). The statistical significance was tested with the Kruskal-Wallis one-way analysis of variance by rank, which is a 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 2 presents an overview of questionnaire results.

Students considered 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 was considered important, both in overall views and in expectations of the course. Students evaluated their own know-how of information sources to be the lowest of the different aspects.

<table>
<thead>
<tr>
<th>Conception</th>
<th>Concrete experience (n = 10)</th>
<th>Reflective observation (n = 26)</th>
<th>Abstract conceptualization (n = 16)</th>
<th>Active experimentation (n = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Information needs</td>
<td>1</td>
<td>10</td>
<td>13</td>
<td>50</td>
</tr>
<tr>
<td>Information sources</td>
<td>4</td>
<td>40</td>
<td>11</td>
<td>42</td>
</tr>
<tr>
<td>IR methods</td>
<td>6</td>
<td>60</td>
<td>14</td>
<td>54</td>
</tr>
<tr>
<td>Information storage</td>
<td>4</td>
<td>40</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Assessment</td>
<td>4</td>
<td>40</td>
<td>14</td>
<td>54</td>
</tr>
<tr>
<td>Access and use</td>
<td>1</td>
<td>10</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>Computer skills</td>
<td>7</td>
<td>70</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>Linguistic talent</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Intermediaries</td>
<td>2</td>
<td>20</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>Individual differences</td>
<td>2</td>
<td>20</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Publishing</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Process</td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>
Students seemed to have a different approach to computer skills and the importance of language in IR than to sources, process, and evaluation. They thought that it was best to have current know-how in linguistic aspects of IR and did not have high expectations of the course from this perspective. The overall importance of computer skills seemed to rank higher than evaluation of information found. Computer and linguistic skills are probably regarded as background skills compared with other elements that are probably linked more directly with IR activities.

There were 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 did not seem to have any remarkable effect on the expressed importance of different elements of IR know-how. Participants with a learning style that leaned toward active experimentation ranked linguistic aspects highest. Learning style therefore is probably more correlated with learning outcomes and performance in learning environment. These aspects can be examined in forthcoming studies within the current project on IR learning environments.

Enrollment types (IS major or minor) strongly correlated with one another regarding expectations. Only students in the master’s degree program ranked computer skills as less important (see Figure 3). Expectations were formed in relation to learners’ conception of their understanding and know-how in different areas of domain. If a student thought that he or she was a skilled computer specialist, he or she probably did not expect development in computer skills in an introductory course on IR; his or her expectations lay in more specialized topics. Expectations of the course and learning environment should be taken into

![Graph](image)

Fig. 2. Students’ expressed importance of different elements of IR know-how. Comp., computer skills; lang., language skills; sour., knowledge of information sources; proc., search process; eval., the valuation of information found.
account similar to conceptions of domain. These expectations have an effect on the overall orientation to the learning situation.

Although there were individual differences, students generally rated themselves as stronger in linguistic and computer skills and weakest in knowledge of information sources. There were, however, some differences between student groups (see Figure 4). Natural science students assessed their current know-how highest in computer skills and linguistic talent, and lowest in evaluation. Humanities students assessed themselves as strong in languages and weakest in knowledge of information sources. The results for social science students were identical to those for the humanities students. Students in the master’s degree program were very self-reliant. They assessed their current know-how as strong on computer skills, process, and evaluation. They considered themselves weakest in knowledge of information sources.

5.3. Second-order analysis

From the analysis of short essays written at the beginning of the introductory course on IR, the following categories of interpretations were formed: process identifiers, source identifiers, searchers, problem formulators, and assessors. Categories were based on the co-occurrence of themes of IR know-how in the temporal phases of the search process (see Figure 5 and Table 6). The bars in Figure 5 representing each group identify what phases of the search process were present in students’ conceptions. The density of shading shows the percentage of participants who mentioned a certain phase in their conceptions (100% = black, 67%–99% = dark gray, 34%–66% = medium gray, 1%–33% = light gray, 0% = white).

The group labeled as “process identifiers” extended the search process most completely. Nevertheless, their conceptions did not cover all aspects of assessment, access, and use as much
as some other groups. Participants seldom explicitly mentioned a process approach. Three students, however, 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 stressed information needs as well as access and use.

“Searchers” concentrated heavily on IR methods and the evaluation of search results, 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 neglected information

<table>
<thead>
<tr>
<th>Type</th>
<th>Phase</th>
<th>Info</th>
<th>Info</th>
<th>IR Met</th>
<th>Info</th>
<th>Assess</th>
<th>Access and use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Need</td>
<td>Sources</td>
<td>hods</td>
<td>Storage</td>
<td>ment</td>
<td></td>
</tr>
<tr>
<td>Process identifiers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source identifiers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Searchers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem formulators</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5. Phases of search process by groups.
sources and retrieval methods. Last, there were participants who concentrated on the assessment phase of process. These “assessors” also covered information sources as well access and use.

6. 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 is the education of professionals in library and information science. This limited 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 on user education in libraries. Bibliographic instruction covers some aspects of IR know-how. This 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 areas other than information studies, such as journalism (Wien, 2000) and education (see, e.g., Hill & Hannafin, 1997; Land & Greene, 2000; Lazender, 2000; Oliver, 1996; Oliver & Oliver, 1997). This rising trend of IR instruction, especially in education, calls for solid research on IR instruction and learning environments.

The results of the current study suggest that learners’ conceptions of IR know-how cover a broad spectrum of IR activities. Analysis of the short essays revealed 12 categories of description as follows: information needs, information sources, IR methods, storage, assessment, and access and use.

Table 6

Students’ conceptions in each phase of the search process

<table>
<thead>
<tr>
<th>Type</th>
<th>Information need</th>
<th>Information source</th>
<th>IR methods</th>
<th>Storage</th>
<th>Assessment</th>
<th>Access and use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
</tr>
<tr>
<td>Process identifiers</td>
<td>9</td>
<td>100</td>
<td>9</td>
<td>100</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>Source identifiers</td>
<td>4</td>
<td>36</td>
<td>11</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Searchers</td>
<td>7</td>
<td>33</td>
<td>7</td>
<td>33</td>
<td>21</td>
<td>100</td>
</tr>
<tr>
<td>Problem formulators</td>
<td>6</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Assessors</td>
<td>1</td>
<td>14</td>
<td>4</td>
<td>57</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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 the search process. Students fell into five qualitatively...
different groups: process identifiers, source identifiers, searchers, problem formulators, and assessors.

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

To develop meaningful learning environments, it is important to pay attention to these conceptions. Learners’ conceptions of the domain to be studied place high expectations on learning environments and instruction. Based on the current research, these requirements are as follows:

- Researchers should understand the effect of qualitatively different conceptions and methods for analyzing those conceptions.
- Researchers should understand that learners construct and interpret information presented in a learning environment in relation to their conceptions—for example, the phase in the search timeline, such as “identify source.”
- 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 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 IR 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.

The implications for design of IR learning environments can be summarized in the following design principles:

- Activate and take into account conceptions of the 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.
- Avoid the passion for gaming.

6.1. 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. Numerous conceptions call for overviews, process approaches, and scaffolds.
6.2. Use a situated and authentic approach

Results of the present study show that learners of IR have a 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) specified 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, whereas the local entity refers to subtasks. 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 transforming sparse conceptions of IR know-how into 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, information sources, and tools makes better sense when working on sufficiently complex real-world problems. There are 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 IR tasks (Brown et al., 1989; Lave & Wenger, 1991; Wilson & Myers, 2000), real-world problems offer possibilities to activate situated cognition and avoid learning that is inert and nontransferable to other situations (Mandl, Gruber, & Renkl, 1996).

6.3. Cover the whole domain through a process approach and scaffolds

In addition to globally authentic activities, different kinds of scaffolding or support can be offered to learners to transform their sparse conceptions of IR into dense ones. There are applicable types of scaffolding in IR instruction as follows: first, giving away parts of solutions of an IR task; second, providing overviews and examples of processes; and third, modeling expert performance (Winnips, Collins, & Moonen, 2000; Winnips & McLoughlin, 2001).

6.4. 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). This method 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. This approach builds 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.

6.5. Avoid the passion for gaming

From 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 Information Retrieval Game, one module of the designed IR learning environment (Halttunen & Sormunen, 2000), could be decreased by scaffolding problem formulation and assessment of search process and relevance of information found as well as articulating 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, teachers might assume the role of critic or monitor 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 with the expert’s or their peers’ performances. This activity is partly metacognitive, because the object of reflection is often a cognitive learning process. Reflection encourages the students to think about their processes from the viewpoint of how they might be different and what changes would lead to improved performance (Collins et al., 1989).

7. Conclusion

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 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 used in constructive learning environments.

Second, methods and approaches to study learners’ 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 the successful design of learning environments. The commonality of IR activities forms people’s conceptions of IR on a much wider scale than previously believed 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 that 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. Student learning style or status as majoring in information studies or studying information studies as a minor subject did not reveal major differences between different student groups, although 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 to analyze 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.

Appendix. Questionnaire from the Introduction to Information Retrieval course (translated from Finnish)

The purpose of this questionnaire is provide a tool to analyze your learning and learning goals. In sections 1 through 3, place an “X” at the point that best describes your conception of the importance of the element. In addition, place either a 1 or 2 after two elements (1 = the most important, 2 = the second most important element) in the space at the end of the scale (_ in every section.

Example:

Topic X: unimportant ____x_________________________ very important (-)
Topic Y: unimportant _______________________ X______ very important (2)
Topic Z: unimportant ___________________________ X__ very important (1)

Section 1. How important is the know-how of the 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 presently evaluate your know-how of the following elements?

Computer skills: no skills ______________________________ skillful (___)
(Same elements as in section 1)

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

Computer skills: unimportant ______________________________ very important (___)
(Same elements as in section 1)

References


