Perspectives on Learning and Knowledge

Learning as a phenomenon has always fascinated people in many different disciplines, and there are many theories and thoughts about what learning is. One can go as far back as to Plato (428 - 347 BC.) to find theories of learning and knowledge (Phillips & Soltis, 1991). Greg Kearsley has built a database (Theory Into Practice) containing 50 theories relevant to learning and instruction (Kearsley, 1994); the theories in this database are all from the 20th century. The TIP-database gives a very broad view of learning theories. Hveem (1992) discusses learning and learning theories as widely different as Skinner, Piaget, cognitive science, and neural nets. Each single theory often focuses on a very particular concept, age or topic to learn, and are not so general.

One problem, but also a great challenge is the fact that there is no theory of learning that is widely accepted (Uljens, 1992). This is not surprising when we take a closer look at learning and discover how broad the phenomenon is. Learning is a complex phenomenon that has many aspects. Age, gender, culture, subject and type of knowledge are examples of parameters that affect the learning – the methods, outcome, etc.

The purpose with this chapter is to study the concepts of learning and knowledge in order to form a theoretical basis for further work with designing interactive learning environment aimed to meet the future. To give a complete overview or list of learning theories is beyond the scope of this thesis, and the ambition of this section is just to give an overview of a few important theories and to emphasise some concepts that are significant for design of computer system that support learning based on comprehension.

1. Different kinds of knowledge

Uljens (1992), puts an interesting question. For a well-accepted theory of learning, how is learning related to different kinds of knowledge? I think that most of us agree that knowledge is a complex concept.
One aspect of the complexity is the wide range of types of knowledge. Compare

1) to know that the capital of Norway is Oslo;
2) to know how to find sources of error in a radio and repair it.

Both philosophy and cognitive science make a distinction between the two types of knowledge illustrated above. Philosophy calls them knowing-that and knowing-how, and cognitive science labels them declarative and procedural knowledge. As another illustration of difference in type of knowledge, compare:

3) to know that second world war started in 1939;
4) to know and understand the complicated situation in the world and specially in Europe after the First World War, that made the Second World War start.

It is one thing to know when a historic event occurred, and another, to know or have an opinion of why the historic event occurred. One last illustration: to know how to perform a process is one thing, but to understand the process, and understand why it leads to the particular effect, is not the same thing.

2. Notions of knowledge

Even if it is hard to find one theory of learning that is widely accepted, among the existing ones, there are a limited number of choices or assumptions that each theory is based on. Suppositions as to what knowledge is, is one of these basic assumptions. Therefore also one of the basic choices that influence the design of an education/learning system.

Why is the notion of knowledge so important? According to Marton et al., opinions of what knowledge is, form a very important part of the cultural platform for the society (Marton, Hounsell, & Entwistle, 1986). In its purest and most obvious form, the knowledge will be visible in the education system. Another way to think about this is to ask what the outcome from learning is. To view learning as a process, is a widespread and accepted view. So it is rather obvious that there is relation between the view of the process, the view of the outcome and the support for the process.

There is a large gap in views of what knowledge is, between “ordinary people” and researchers and academic people. There is a very positivistic attitude to knowledge spread in the community. The media maintain this attitude by all the time asking right-or-wrong questions in their quizzes; why-questions are hard to find.
A very common way to judge a person’s knowledge is by her ability to answer questions in the periphery of a specific subject. The whole idea is built around the notion that knowledge is quantifiable, and there always exists an absolute, right answer to any question that can be put.

Is there a problem with this positivistic view on knowledge? That depends on your perspective. It is easy, with this view, to measure the outcome and to judge a person’s knowledge. In the short description above it looks as if this view only tolerates knowing-that-knowledge, but both declarative and procedural knowledge can be accounted for in this view; however, as I see it, the positivistic view lacks the why-knowledge. A person that is educated in an educational system built on this view, how well is such a person prepared for making own judgements, critically examine phenomena, and for reading (in a wide sense) in order to understand? The concept of knowledge should include also the why-knowledge. In the phenomenological position of pedagogy one discusses in terms of comprehension of phenomena (Marton et al., 1986); more about this approach later on in this chapter. What is the view on what knowledge is in other scientific disciplines? In an attempt to answer that question I will make a survey of some scientific disciplines that I see as important and interesting for computer-based learning environments. The disciplines that this survey covers are: Plato’s theory of learning and knowledge, pedagogy and mostly the phenomenological approach, cognitive science, and information science.

3. Learning styles

Some people prefer concrete examples, other abstract reasoning, some people read the summary of a book first, other read a book from cover to cover; these are examples of how different we are in a learning situation. There are several attempts to theorise ways of learning; Dunn Learning Style Model and Kolb Learning Style Model are two examples described in (Hein & Budny, 1999). The purpose with this section is to introduce the concept of learning styles, exemplified with the Kolb model.

The main difference between Kolb’s and Dunn’s models is that Dunn argues that all individuals have their own individual learning style, whereas
Kolb defines four kinds of learning styles based on four learning modes:

- **the concrete experience mode** is characteristic of people who feel more than they think – learning from feelings (Hein & Budny, 1999; Henke, 1997);

- **the reflective observation mode** is characteristic of people who would rather watch and observe others than be active participants – learning from watching and listening (Hein & Budny, 1999; Henke, 1997);

- **the abstract conceptualisation mode** is characteristic of people who think more than they feel, and analyse problems by some systematic method – learning by thinking (Hein & Budny, 1999; Henke, 1997);

- **the active experimentation mode** is characteristic of individuals who welcome practical applications rather than reflective understanding as well as actively participating rather than observing – learning by doing (Hein & Budny, 1999; Henke, 1997).

The diverger, the converger, the assimilator, and the accommodator represent four kinds of learning styles that Kolb has identified in his work (Kolb, Rubin, & McIntyre, 1979), (see Figure 7):

Converger – a person who wants to solve a problem and who relies heavily upon "hypothetical-deductive reasoning...to focus on specific problems" (Henke, 1997). The dominant learning abilities are abstract conceptualisation and active experimentation (Hein & Budny, 1999). The positivistic view on knowledge and learning permeates this mode.

Diverger – a person who solves problems by viewing situations from many perspectives and who relies heavily upon "brainstorming" and "generation of ideas" (Henke, 1997), i.e. creativity is a key concept. The dominant learning abilities are concrete experience and reflective observation (Hein & Budny, 1999).

Assimilator – a person who solves problems by "inductive reasoning" and "ability to create theoretical models" (Henke, 1997). The dominant learning abilities are abstract conceptualisation and reflective observation (Hein & Budny, 1999). People in this category prefer when information is detailed, logical, and orderly.

Accommodator – a person who solves problems by "carrying out plans and experiments...and adapting to specific immediate circumstances" (Henke, 1997). The dominant learning strengths are concrete experience and active...
experimentation (Hein & Budny, 1999). Communication with other people is central for people in this category.

Even if there are differences between Dunn’s and Kolb’s models for learning styles, they agree that learning style is something that changes over the time, that learning style varies between individuals, and that it is good for the outcome if both teachers and learners in the learning situation are aware of this, and the learners are aware of their own learning style.

To be useful such models requires methods to determine individuals’ learning style. Both the Dunn model and the Kolb model have methods to identify learning style (Hein & Budny, 1999).

4. Platonism

Plato’s theory of learning and knowledge has more historical than practical interest, but there are a couple of concepts that are interesting to pick up and use in a model for computer-supported learning.

Some time around 370 BC, Plato founded the Academy, one of the most famous and well-known teaching institutions in the world. The Platonic way of teaching uses examples and stories in a dialectic style of teaching.

Plato’s ideas about learning include six fundamental points. First, knowledge is innate, all human individuals are born with all knowledge placed in their minds (Phillips & Soltis, 1991). The problem is that a newborn child has not learnt to see her knowledge. Second, to learn, is “learning” to see or discover the innate knowledge. Third, reincarnation is a source for knowledge, it is in the moment of reincarnation that the individual
gets her knowledge. Fourth, the learning situation should be a one-to-one situation, with one master and one learner. Fifth, the learner’s knowledge should be recovered by the master or the master should draw out the learner’s knowledge. Sixth, new knowledge is always built on old knowledge.

What has the Platonic view of knowledge and learning to add to a model for computer-supported learning? Reincarnation and innate knowledge are easy to reject. Even if there is a risk that the master oppresses the learner in the learning situation it is harder to reject the master-learner situated learning style; there is much in this style of teaching that is good. One of the best things is the active role of the learner. An active way to entrench one’s knowledge and an active way of processing knowledge promotes good learning, I think. The dialogue in a master-learner relation is an element that has the possibility to force the learner forward in her active knowledge establishment. The view that new knowledge builds on old knowledge, gives an approach to what knowledge is that implicates that learning is a generative process.

In summary, there are mainly two elements in the Platonic learning theory, that are useful in a model for computer-supported learning:

- the view of old knowledge as a platform for new knowledge;
- the active way of dealing with knowledge.

5. Perspective of pedagogy

The area of pedagogy traditionally takes a positivistic and quantitative view on knowledge and learning, and much of the research in this area has been focused on the teacher-side of the learning situation. The positivistic idea of knowledge implies that there always exists one right answer and all the others are wrong, and the quantitative view of knowledge implies that one measures knowledge in the amount of right answers. The phenomenological approach has quite a different view. From their point of view, knowledge is understandings of phenomena, and learning is viewed as a process where these understandings are changed; this is a central principle.
Other important features of the phenomenological approach are:

- the analysis of the outcome of the learning process in qualitative terms;
- the move of focus, from the teacher-side to the learner-side of the learning situation;
- the view on learning as a generative process, which is constantly going on.

According to the phenomenological approach, it is possible to identify qualitative differences in understandings of phenomena, consequently knowledge can be judged by its quality. This idea to identify qualitative differences in the outcome from the learning process can be utilised in many ways. For example, to make assessments, to guide students and to evaluate models of learning environments. The functional relationship between the level of outcome from the learning process and the strategy or the level of processing that the learners use, is the result from the phenomenological research which is the strongest and also one of the most interesting. Also the results related to the choice of learning strategy and how it is ruled to a high degree by factors of motivation and relevance for the subject have great interest for the design of tomorrow’s learning environments.

The phenomenological approach to learning

The TIPS-project (Tillämpad Inlämningspsykologi och Studiefärdighet), started in July 1970 by Ference Marton and Lennart Svensson among others, can be viewed as the starting point for the phenomenological approach to research on learning. The project had three major research questions (Marton, 1974):

1) How can one in a fruitful way observe and describe knowledge?
2) How can one observe and describe study skill?
3) How can one affect study skill?

To find an answer to the first question, an experiment was made. There were thirty subjects. The experiment was divided into three sessions and the time between the sessions was about five weeks.
The scheme for the first session was:

- all subjects read a text;
- free reproduction of the text;
- introspective questions about the learning and memorising process;
- answer questions about the text;
- word recognition test;
- answer questions about the study process.

The scheme for the second session followed the scheme for the first session except for two changes: all the subjects first performed a free reproduction test of the text from the first session, then they had a new text to read and do the various tasks with. The scheme for the third session was:

- free reproduction of the text from the second session;
- answer questions about the text from the second session;
- examination for the subjects ordinary course;
- answer questions about the study process.

Details of this experiment are given in (Marton, 1974; Marton, Hounsell, & Entwistle, 1984). Below, some of the findings from the TIPS-project that are interesting in a design and discussion of computer-based learning environment are discussed. This discussion can be viewed as summary of the answers to the three major research questions that the project started with.

**What is knowledge?**

The researchers in the TIPS-project reject the traditional positivistic view on knowledge, on which knowledge can be described in quantitative terms and is measurable. Instead they propose an alternative view, on which knowledge is described in qualitative terms focusing on the message or the point in the text. In this context “text” has a very broad sense – it could be a written text, a talk, a video or some other sort of presentation of information. They see knowledge as a comprehension or attitude to a phenomenon and they see learning as a change of comprehension and attitude to the phenomenon in question. But, is it not the case that either one grasps the point of the text or not? And then we would still be stuck in the positivistic view. The answer is no, because it is possible to describe the understanding of the text in qualitative terms. The TIPS-project shows that it is possible to find clusters of subjects with same level of understanding of the text and these clusters form a hierarchy of levels of outcome, as they are called. The
number of levels of outcome depends on the character of the text and the phenomenon that is described in the text. As an example, in the experiment described above, four levels of outcome were found.

- **Pre-structural** – No correct elements are present. The questions and responses are confused. This may be because no serious attempt has been made at addressing the question, the questions are merely restated, or an incorrect “guesstimate” has been made.

- **Uni-structural** – One correct and relevant element is present.

- **Multi-structural** – Several relevant elements are present but are independent of each other, often in a list form. An unwarranted conclusion may be offered without considering all the presented data.

- **Relational** – The relevant elements are integrated into a conceptual schema. Student produces an argument rather than a list. Process of induction leads to conclusion which is not qualified, i.e. an over generalisation. No alternatives are offered.

- **Extended Abstract** – As Relational, but the whole is generalised to display a wider appreciation of the subject. The response is taken outside the confines of the original problem and cites other data and contexts. This would be evident in a first class answer where the student realised that behind a question were related questions which drew on other related issues and knowledge. Process of deduction resolves inconsistencies, draws analogies, considers alternative and qualifies conclusions. This is the sort of answer that is required when a lecturer says that they have written a question that will stretch the brightest student. They may well refer to “little twists” in the question, these are not tricks but rather an opportunity for you to display a real appreciation of subtleties of the subject.

*Figure 8. The SOLO-taxonomy – adapted from (Biggs & Collins, 1982; Hughes, 1995).*

The methods used to find these levels are of interest to see how well one can utilise the concept of *level of outcome* in a fruitful way. There are two main phases. The first is to identify the ways in which one can understand the text. The second is to classify each person. The whole process calls for very extensive reading by the evaluator. There are mainly two types of texts that
are used in the evaluation process: free reproduction of the texts, and answers to the questions; in one or two sentences point out the meaning of the text. In *The Experience of Learning* (Marton et al., 1984), SOLO (Structure of the Observed Learning Outcome), a method to find levels of outcome in a particular learning situation is presented. The taxonomy has five fixed levels of outcome and is general with regard to the topic of the text, (see Figure 8).

If one discusses the phenomenon of learning taking a qualitative view on knowledge, and also accepts the notions of level of outcome and outcome space, then the next great challenge is to find explanations to differences in the outcome and find methods to help or support students to get a deeper understanding of the meaning of the text.

**Level of processing text**

One of the first explanations to differences in the outcome one comes to think of is that the students’ previous knowledge and linguistic skill differ in an essential way. But in the first experiment the researchers had taken this possibilities under consideration in the choice of text. The language is rather simple and the subjects have a similar background so that their previous knowledge is similar. Such considerations are not easy to make at all times, and specially not in a real learning situation. Although previous knowledge and linguistic skill generally have an impact on the level of outcome in a real situation, there must be other factors that account for the results.

Another explanation is that students’ “cleverness” differ, but the text is rather simple, so one can reject this explanation, too. The most reasonable explanation to the differences in the level of outcome put forward in (Marton et al., 1984), that there are differences in the learning process between the learners.

More particularly, differences in *level of processing* were revealed in the first TIPS-experiment. Using structured interviews with each of the subjects about their way of processing the text and their ordinary style of studying, the researchers found a rather simple explanation why some of the students fail to find the meaning of the text. One category of subjects do not search for any deeper understanding of the text; they focus on the surface of the text. They also have as a goal with their studying; to memorise the text in order to be able to reproduce it as well as possible. Another category of learners have the focus on the deeper meaning of the text. This latter group of learner use the text as an instrument for learning and not as a goal, like the first group of learners do. These two distinct ways of processing the text are labelled *surface directed* and *depth directed*. 
One of the more interesting results from the TIPS-project is the strong correlation between level of outcome and level of processing. As Figure 9 indicates, subjects with surface directed style of processing the text tend to get a weaker understanding of the text (a lower level of outcome) and subjects with depth directed style of processing text, tend to get a stronger understanding of the text.

If there are mainly two different styles of processing text, and one of them leads to a deep understanding of the text, and one leads to a shallow understanding of the text, it becomes very interesting to try to change the level of processing of the learners who are using a surface directed. Is it possible to change a person’s style of processing text? If it is, how should one do it? What is the distinguishing quality of the depth directed style?

An attempt to answer these questions are reported in (Marton et al., 1984). The first question that the researchers worked with was the question about the distinguishing quality. Analysing the answers from the process question from the first experiment in the TIPS-project, it appears that depth directed subjects were using the text very actively. An important part of these learners’ method of studying is to engage in an active dialogue with the text, meaning that one asks oneself processing questions (questions about the meaning of the text). In this active dialogue the learners also relate their interpretation of the meaning of the text to a wider context – to the learners’ own experiences and to knowledge that they already have.
From this analysis the researchers got the following idea of how to change the shallow learners’ level of processing. Prepare the text with processing questions, in the same manner that the depth directed subjects do. Give instructions to the subjects to answer these questions. Then more subjects should grasp the point of the text and reach a deeper understanding, i.e. a higher level of outcome. When such an experiment was made, the results ran in the opposite direction, however – the proposed method did not increase the understanding of the text. It was clear, that the learners did not change to depth directed style, but instead quickly adapted their a style of reading to a surface directed search for answers to the processing questions as the main activity in their studying. This is a good illustration of the well-known fact that we human beings are very good at adapting to the current requirements. There are lots of evaluations reported in the pedagogy literature as showing that learners adapt their style of studying to the expected examination form.

In retrospect, the above idea of how to affect a person’s style of processing a text seems rather naive. If one thinks about the problem for a while and take an introspective look at one’s own way of processing text, one realises that it is very much a question of attitude and motivation. Impositions are not always the best of motivations. Somehow, it should be possible to get more learners to use a depth directed way of study, but how?

**Motivation**

We know that there is a strong correlation between, the level of processing and the level of outcome in a learning situation. Why then, are not all learners using a depth directed way of studying? Several factors influence the choice of direction of one’s study, among them are: motivation, attitude, and culture. I believe that one thing that one must have in mind in this case, is the fact that most of the learners are not conscious or not reflecting on the level of processing that they are using. If you are not aware of the conditions you can not change them. One thing that can be done is to inform the students that the correlation between the style of studying and the outcome exists. There is also a correlation between the way one uses the text, as a goal or as a instrument, and the level of processing, making the level of processing also a question of attitude.

Motivation affects the level of processing. It is possible and fruitful to make a distinction between internal and external factors of motivation. The internal factors are those that individuals set up for themselves, for example: I should study this because it is fun; since I am interested in environmental questions it is valuable for me to study chemistry. The external factors of motivation are the factors that are set by the environment, the circumstances, for example: culture, parents, possibilities to get a job, the view on
knowledge that rules, and examination forms. Marton et al., (1986) reports an experiment where the goal was to determine the relation between factors of motivation and the level of processing. The main result of this experiment is a strong correlation between internal factors of motivation and depth directed of processing, and between external factors of motivation and surface directed processing.

Relevance of the content

One factor that has strong connections with motivation, is the degree of relevance of the content of the text. If the learners believe that the context is relevant for them (and their purposes) they will be better motivated. When reading a text or attending a seminar, the content can have relevance for me for many different reasons, and be relevant from several perspectives. It is fruitful to make a distinction between internal and external relevance of the content, paralleling the distinction between intended and external motivation, as demonstrated by another experiment, with a goal to evaluate factors of relevance in a learning situation (Marton et al., 1984). External relevance means that the learners connect the content of the text with factors they can not control. Internal relevance means that the learners are trying to connect the content of the text to their own personal understanding and comprehension of the phenomenon described in the text.

The same experiment indicates a correlation between factors of relevance and the way a learner studies. Individuals with a strong external relevance studies in a way similar to individuals with a surface directed style of studying. Consequently learners with strong feeling of internal relevance studies in a similar way that individuals with a depth directed style of studying studies.

The researchers also found a third kind of relevance factor, labelled substituted relevance, that has a close connection to the performance of the teacher. The substituted relevance is qualitatively different from the other two. These learners with substituted relevance seem not to relate the content to either external or internal factors as the learners adopting the other two forms of relevance do, instead they seem to relate the content to things that the teacher offers them. This could be enthusiasm, interesting illustration or examples that the learners can identify their selves with. Marton et al. think that the substituted relevance is the most interesting level of relevance that was discovered, because it emphasises the important role of the teacher, in instilling and awakening the lacking or dormant internal relevance of the individual student.
A second result from the same experiment is, that the relevance is affected by three distinct parameters: the learner’s attitude to the text/course, the context of the teaching and learning, and the learner’s background knowledge and familiarity with the topic.

Phenomenological approach and knowledge work

I believe that the phenomenological approach to learning and the qualitative attitude to knowledge has much to add to a pedagogical model based on requirements and values from the knowledge society.

First, the phenomenological approach to knowledge can add new methods to evaluate a learning system. Specifically two methods to evaluate and decide the outcome level are available: TIPS and SOLO. Both methods can be used to evaluate a model for computer-supported learning. The main difference between them is that SOLO has a fixed number of level of outcome, whereas TIPS has a variable number of levels, depending on the particular context of application. Both methods have their drawbacks and advantages. The main drawback with TIPS is the demanding process to decide which the possible levels of outcome are. In TIPS the levels of outcome are dependent of the topic of the text. There is also a dependency between the level of outcome and the questions that are used in the evaluation and the presentation style of the text. The context dependency in the TIPS-method is the strongest advantage over the SOLO-method because more variables can be evaluated with the method. The evaluation process is an important part in designing and constructing a computer system or model that supports learning, but it is also desirable to convert these methods (the TIPS-method and the SOLO-method) to cognitive tools for learning.

Second, if one accepts the qualitative attitude to knowledge and learning, many interesting results from the phenomenological research on learning can be utilised in a model for a computer system that supports learning. Particularly important, I believe, are the relations between level of outcome, level of processing, motivation and relevance; and the relationships between these are almost functional. The level of outcome depends on the learner’s level of processing. The kind of motivation, and the kind of relevance of the topic, are two important factors that affect the level of processing, (see Figure 10).
Internal motivation factors and internal relevance lead to a depth-directed level of processing which in turn implicates a better understanding or higher level of outcome.

In a model for teaching that builds on the above results, the individual needs and requirements must be in focus in order to ensure a high degree of internal motivation and internal relevance. These things seem to go hand in hand with the requirements set by the new approach to learning, mentioned in the introduction. The model for teaching should focus on the learner’s own experience and interest in the topic. The results is a style of teaching which is very free and focused on the learners. One conclusion from the above discussion is that the model must include elements where the students can try to set the topic into a context and relate it to things, situations, events that are relevant to them. One such element could be an open hypertext environment. With open I mean that there are possibilities to search for information external to the course material, possibilities like those offered by the WWW.

The type of relevance that the researchers in the TIPS-project found most interesting was the substituted relevance, and it seems that the teacher plays an important role in strengthening this relevance factor. Through the substituted relevance the learners tend to change their attitude towards something more like the internal relevance. My opinion is that other learners, studying the same topic, are almost as effective in promoting such change in attitude as the teacher. Specially if the learner has the opportunity to see how the other learners have worked and are working with the topic. It is important to include this attitude-changing mechanism in the model, I think. An open hypertext system might work in this case, too. It would be
open in a wider meaning, letting the learners view how other people
(learners and teachers) have worked with the topic.

The above discussion deals with how one can strengthen the internal
factors of motivation and promote the internal attitude to relevance, for the
learners. But we can not stop here. The system or the model must also
support the learners in their depth-directed way of studying, to maintain the
internal motivation and the internal (attitude) to relevance. Active reading
was one of the most salient characteristics that the researchers (in TIPS-
project) found when they made a study of the characteristics of depth
directed studying. What elements should the model include to maintain
internal factors of motivation and relevance? Active reading has at least four
components: exploring, forming, analysing, and administrating.

**Explore** – The ability to study the topic partly in the course material and
partly by searching for material that is relevant in the learner’s personal
context (on one’s own).

**Form** – The ability to form and process the text: by adding notes, making
references to other relevant material, by changing the structure of the texts,
change the text to fit the learner’s understanding and previous knowledge,
and more.

**Analyse** – The ability to analyse the topic and/or the intended meaning of
the text, ask oneself processing questions, working with the structure of the
text, or by analysing how oneself and other learners have worked or
processed the material.

**Administrate** – The ability keep track of the exploring, forming and
analysing activities by administrating source references, recording how one
have worked with the text, which questions one has asked oneself, etc.

All these activities involve communication, for example in viewing and
taking part in other learners’ and teachers’ ways, or proposed ways of
working with the material. One thing worth noticing is that the role of the
teacher in this model tends to shift from being a knowledge transmitter to
acting as a designer and guide of an information system.

In the traditional learning situation, the classroom, there are two
intelligent groups of participants, the learners and the teacher. In work on
computer-based learning there are three possible approaches to the question
of intelligence; Lajoie and Derry defines these three approaches (camps) as

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7 The concept of intelligence is often discussed. My view of intelligence is wide, implying that
intelligence is very hard to measure and includes many skills that one does not evaluate in a
traditional IQ-test.
modellers, non-modellers, and a mid camp (Lajoie & Derry, 1993). The modellers attempt to put some kind of intelligence into the computer system using it to control the instruction (artificial intelligence has a long history of application to using computers in a learning situation). The non-modellers, considering how difficult it is to build in any useful intelligence in the system, choose to accept that the only intelligence in the learning system is the learner’s own. The above discussion of what the phenomenological approach has to add to a model for a computer system that supports learning, is very much in line with this approach, assuming no intelligence in the computer system. Still, the other approach, using artificial intelligence, is also compatible with, and could benefit from the phenomenological approach. The best solution I believe, is a combination, which comes closest to the approach taken by the mid camp: one does not deny the usefulness of artificial intelligence, but proposes a computer-based learning environment where the learners have more control over their own learning situation than in the typical “intelligent tutoring system”.

The concept of active reading includes a style of processing text in which the learners develop their understanding (for the intended meaning) of the text in a kind of “dialogue” with the text. By adding a guide or an intelligent dialogue partner, the learner can get a more active and “real” dialogue. Such a softbot would be an intelligent agent helping and supporting the learner to navigate, to search, to retrieve, and to orientate in the information landscape. For this to work the softbot must be under the learner’s control and utilise the results from the phenomenological research.

To summarise, the most useful elements from the phenomenological approach to learning and knowledge for a model or system that support learning are:

- the qualitative approach to what knowledge is;
- the evaluation methods that evaluate from a qualitative perspective;
- the functional relations between level of outcome, level of processing, motivation, and relevance of the topic;
- the characteristics of the variables level of outcome, level of processing, motivation and relevance.

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8 A softbot is a software robot, that is, a “robot” that is pure software with no mechanical parts, and acting in a world consisting of information and software (CACM, 1994).
6. Perspective of cognitive science

The study of cognition has a long history that goes back to the old Greeks – behaviourism, information processing approach, connectionism, and the situativity theory are approaches from the 20th century. The area of computer-based learning environments has been strongly influenced by the scientific results from disciplines with a focus on human mental abilities. For example, the behaviouristic movement is the origin of the idea of programmed learning and CAI environments. Later, results from the information processing approach (which points out the functionality and limits of the human mind) has been the basis for ITS environments. All these approaches imply that there are many ways to view knowledge, varying from the connectionistic and behaviouristic ways, which are very clinical in their view on knowledge – knowledge is to have the right connections between input and output – to the situativity theory’s view where knowledge is seen as a social construction in which individuals participate in social contexts. The information processing approach has a level of abstraction – in the discussion of knowledge and learning – that lies between behaviorism and situativity theory. In the information processing approach, knowledge is identified with internal representations of the environment.

According to the behavioristic and the connectionistic way of looking at learning, learning is in some sense to drum knowledge into a person’s head; a learning situation where the learners have a rather passive role. According to the information processing approach, learning is a question of acquiring the right representations of a procedure or a concept, which is done through interactions with the environment. Consequently, in the view of the information processing approach, knowledge is something that can be transferred between individuals – a notion that strongly affects the methods for teaching which the approach promotes. Also this approach provides a learning situation with rather passive learners. Situativity theory is an approach in which the importance of learners taking a more active role is pointed out as essential. Knowledge is seen as something that individuals construct in a process of interaction with both the social and the physical context.
To summarise, the most useful elements from cognitive science for a model or system that supports learning are:

- the memory hierarchy and the performance and limits of the different memory subsystems;
- the functional relations between the level of processing and the performance of the memory process;
- the similarities between some concepts from cognitive science and the phenomenological approach, e.g. level of processing;
- the importance of the context for the outcome of the process of learning; the social as well as the physical context.

7. Perspective of information science

The main purpose of this section is to describe the parts of information science that I believe have something to contribute to a pedagogical framework for the learning environments of tomorrow. The description of information science is mainly based on Ingwersen’s *Information and Information Science* (Ingwersen, 1994).  

Information, data and knowledge

Information, data and knowledge are three concepts that stand in a relatively close relation to each other. To several disciplines, they are central concepts, such as information science, which has information in focus, and pedagogy and cognitive science, in which knowledge is in focus.

Information science is concerned with large information spaces. Traditionally, much of the information has been stored as paper documents, and physical documents have been considered as true information, but the concept of information covers more than physical documents. “On the one
hand information is the results of a transformation of the generator’s
cognitive structure (by intentionally, model of recipients’ states of
knowledge, and in the form of signs) ... on the other hand it is something
that when perceived, affects and transforms the recipient’s state of
knowledge.” (Ingwersen, 1994). The question is where the limits are for
what one should call information. According to Ingwersen, in an information
science perspective the concept of information must satisfy dual
requirements – information is something that must be generated in some
sense, but if there is no one who perceives it, the generated information is
only potential information or data. Some of the concepts in the quotation
above may improve our understanding of the concept of information, as well
as our understanding of the concept of learning and knowledge.

The current conception within information science of how the information
users work with information systems is in outline as follows. People are
working with some specific task, for example some process of problem
solving, when at some point they get a feeling of falling short of information
(knowledge) needed to solve the task. This situation is the origin of a desire
for information, it causes a need to search for information and retrieve
information from some information system. There are ideas in information
science about the desire for information as the driving force for producers to
produce potential information, and also that the existence of the enormous
amount of information produced in today’s society is a result of a desire for
information. Therefore, the concept of desire for information is central in the
theory of information science.

There are two main approaches in information science: the human-related
approach and the rationalistic approach; and the main differences go back to
the view on information and the role that information plays in information
systems. The differences are reflected both in the methods used to analyse
information, in the involvement of users, and in the cognitive aspects of
information systems. The question of methods for analysing text, is mainly a
question of matching the user’s desire for information with information
available in the information system. As the name suggests, the rationalistic
approach has a rationalistic view on information: information is just a matter
of characters and texts, and getting information from the generator side to
the consumer side is just a matter of transferring characters. Hence, the
methods used in this approach are typically statistical methods, such as
measuring word frequencies in documents. The user aspects of information
systems are very limited in this approach. On the other hand, the human-
related approach discusses information systems in terms of the user aspects.
Also, they extend the concept of information from the character and text
level to a level where the material is assigned some meaning (semantic), and
this “meaning” is a mapping of the producer’s state of knowledge. Methods for analysing the information are on a deeper level. This extension of the concept of information indicates that cognitive aspects of information systems are considered by the human-related approach. Another indication is that one discusses the users’ desire for information in terms related to cognition, such as state of knowledge, problem space, and state of uncertainty, and interactions between these (see Figure 11).

**The rationalistic approach**

![Diagram of the rationalistic approach](image)

**The human-related approach**

*Figure 11. The cognitive communication system for information science, adapted from (Ingwersen, 1994).*

Information and information systems are complex concepts in many ways, which causes problems for their practical application. The factor of time and linguistic ambiguity are two such complications that cause problems. The growing amount of relevant material that for example a scientist has access to, and the limited resources that the same person has to perceive and process this amount of relevant material, creates a gap between what one wants to do and what one can do with the relevant information one has access to – a phenomenon known as information overload. Both the question of information overload and ambiguities in information are discussed below.

**The dimension of time and uncertainty of information**

From the information science perspective, every piece of data has a possible information value, and when data is perceived it is assigned an actual information value\(^{10}\) by the recipient. A common conception is that the information value is a constant attribute – a perceiver has once and for all assigned a value to a particular piece of information – but in fact, this is not really true. The information value for most information is changing all the

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\(^{10}\) Kristo Ivanov’s concept of information quality is closely related to the concept of information value, see (Ivanov, 1986).
time, in an information life cycle (Ingwersen, 1994). This fluctuation is caused partly by the time factor, and partly by variations in the individual’s way of perceiving and interpreting the potential information in the current context. The length of the information life cycle differs among different kinds of information, from information like warnings and calls for attention with a very short life cycle, to information like scientific documents, with a rather long life cycle.

Sometimes (and too often in the world of the WWW) what happens is that material loose all its intended information value (the value that the producer assigns the information) and becomes almost worthless (dead information). On the other hand, there have also been cases where information or material with very low information value have been “rediscovered”\(^\text{11}\), and got a high information value again.

Time plays an important role for the value of information. One aspect of the discussion about time and information value involves the fact that the same data can generate different information at two different moments in time for the same person. There are two different linguistic meanings\(^\text{12}\) of the sentence, ‘The man hit the boy with the stick’, and each time one reads it the meaning may alter.

The information value of a phone book exemplifies another phenomenon which also has to do with the dimension of time. The information value of a phone book has much to do with completeness. Phone books are being regularly updated, and a phone books loses much of its intended information value when a new version is produced and distributed. Regardless of the fact that the set of phone numbers you actually retrieve from the phone book is very small, and most of the numbers are never used by you, this change of information value will always happen – it is a “necessity” to have a complete and updated phone book. Still, an old version of a phone book keeps some of its information value, but this value has now more of a cultural or historical character, and has nothing to do with the phone book’s intended information value. Religious texts like the Bible or the Koran, that have information values with great complexity, can be used to illustrate one other aspect of the concept of information value. For some people these documents are historical documents of different cultures. For other persons these books have the role of a law book that rules their way of life. The example with religious texts shows how intricate the relation is between the

\(^{11}\) Maybe information archaeologist, and information space explorer, are professions for the future.

\(^{12}\) The man has a stick that he hit the boy with, or one of the boys has a stick, and the man hit that boy.
information value and the interpreting individuals. All these complications with the concept of information value can be transferred to situations with different kinds of material and media, and in particular to learning situations. Clearly, the concept of information value is much a matter of quality, and a discussion about the value of information in terms of reliability and completeness of information is relevant.

Kuhlthau has studied the process of information seeking from a user perspective. She has found that this process consists of six phases (Limberg, 1993), where formulation of goals and desires is the first phase. This is also one of the most important phases for the outcome of the seeking process. Linguistic ambiguities may cause problems in the formulation of desires, and this together with the fact that the material or data is ambiguous in its nature, leads to a twofold ambiguity in the retrieval process. Because of the difficulties to formulate desires in an unambiguous way and the uncertainty in the information value of stored material, it is hard to deliver relevant material to the users. Therefore, there is a great need for languages to express desires, that are good at capturing the real desires, and there is a great need for good representations of the information value of the material, at least the intended value.

Meta-information

In traditional information systems like libraries and databases with articles, there is much information stored about the information. *Meta-information* is a general term for information about information. For example, meta-information can be keywords, abstracts, different classification systems, index tables, information about the author, etc. Commonly, these types of meta-information – especially indexes and classifications – are used to make the process of matching the user’s desires with the contents of the information system easier and more effective. That means that the use of meta-information has a purpose of making it easier to search the information space, or in other words, it is an attempt to solve some of the problems of time and uncertainty – the problems that are related to matching the user’s desires. Still, much of the available meta-information is very static, disregarding the fluctuations in the information values. The problem to construct an index (i.e. meta-information) of information with dynamically varying information values, is commonly referred to as the interindexer, or (in)consistence, phenomenon of information (Ingwersen, 1994). It is clearly not enough to work out the meta-information once (and for each individual that uses the system) – it needs to be formed dynamically according to the
current cognitive state (state of knowledge, state of problem and state of uncertainty) for each of the users (which seems to be a very hard task).

Informetrics is an area that deals with certain kinds of meta-information. Many of the methods of informetrics are used for the purpose of analysing changes in the information value of documents. For example, with co-citation analyses together with different clustering methods it is possible to see how the centre of gravity for a research area is changing over time, which persons are most influential in the area, concentrations of peoples, etc. I believe that these informetrics methods can be useful on a smaller scale on an individual basis, in working situations where searching and exploring plays central role, but also in more traditional working situations. For example, these methods based on clustering techniques may be used in a fruitful way to see how an individual has worked with a subject or area, to get information about which parts an individual has worked a lot with, which areas in the information space the person has visited, and to find other persons with related interest, to find other useful information resources (clustered by use patterns), and much more. I believe that these methods can also be of help for the individuals to keep their focus, which is becoming a big problem for the users of very large information systems, like the WWW.

The uncertainty that is involved in an information system has serious practical consequences, too, such as the problem to match user desires with the stored information. It may seem as if this uncertainty in information only has negative consequences, but it also has positive aspects. For example, in a learning situation, it would be unfortunate if the space of potential information only consisted of unambiguous data. The process of interpreting linguistic information, and picturing information, is a very stimulating and creative process. According to the phenomenological approach to pedagogy, learning is very much a matter of creating a personal way to understand phenomena.

Information overload

In the world of today, when the information society is becoming a reality (at least in the industrialised part of the world), information has more or less become a merchandise, and the growth in the amount of information is awesome. Of course, this has consequences for the commercial manufacturers as well as for society at large, and for the scientific world. To give exact numbers of the growth rate is of course impossible, but a common conception is that the amount of publications in the scientific world is growing exponentially (Solla-Price, 1986). According to Wilson (1993), scientists tend to value the production of information more than the
consumption of information, and that is a reason for the rapid growth of information. "Information overload is the existence of a gap between what one can do and what one wants to do or think one should do with existing information. ", (Wilson, 1993).

Wilson discusses some of the consequences the phenomenon of the growing amount of information has for the scientific community. For example, it becomes harder and harder for scientists to keep their knowledge up to date as more information is produced. Wilson thinks that it is not the existence of huge amounts of information that is the main problem, and I am prepared to agree with him about this, since, in fact, we have rather good methods for managing huge amounts of information. Instead, Wilson\(^{13}\) points out information overload as the real problem for the scientists. The root of the problem is some common assumptions about rationality and efficient use of information. "One standard view of rationality includes the condition that rational decision and rational belief formation require the use of all available relevant information", (Wilson, 1993).

Wilson refers to empirical evidence that the scientific society is inefficient in its use of relevant information. For example, it is common that scientists fail to use late incoming articles that have impacts on their results. Information overload is a big problem to handle and manage in itself, but there are things that makes the situation even worse. For example, conceptual changes – attitudes to which issues or approaches are the “right ones” for the moment are constantly changing in the world of science. This fluctuation causes even more trouble for the scientists when trying to keep the knowledge up to date. It is not only the new information that one must handle and manage, the conceptual changes causes some of the old information to become relevant again, a scientist must manage this as well, in order to be up to date (compare the discussion above about the life cycle of information).

How do people respond to information overload? There are, mainly two ways in which people normally respond, and both have to do with cutting back the incoming stream of relevant information: specialisation and satisficing\(^{14}\). Beginning with satisficing; when should one be satisfied with the amount of information that one has processed? One rather simple strategy, is to constraint the search routines. For example, use a specific time

\(^{13}\) I am not sure that it is Wilson who coined the term information overload, because Wilson refers to a paper written by Eugene Garfield with the title, Scanners of the world unite: you have nothing to lose but information overload when he discusses the concept.

\(^{14}\) Satisficing as a term for resource-limited rationality, was introduced by the economist and cognitive scientist Herbert Simon, one of the persons behind the well-known General-Problem-Solver, a computer system modelling human problem-solving ability, constructed around 1960.
limit, or set an upper bound to the number of items that will be retrieved. Another way is to handle the state of satisfaction as if it was normative. For example, one has read the most important works in the field of research, or similar criteria. That means that someone must estimate the amount and quality of information that one has taken under consideration. The problem with that is to decide who has the ability to judge, and which rules the judgement should be based on. However, in the world of science it is this latter procedure of reaching the requirements of satisficing that people commonly work with – it is part of the scientific skill to judge, and to know what the rules are. Specialisation is to make one’s field of interest more narrow. A common reason to narrow the field is to make it easier to maintain the level of one’s expertise knowledge. Specialisation can be done in two ways. The first alternative, is to narrow the field of interest by redefining the group of relevant people that produce material in the field. An effect of this strategy is that one tends to cut off the information stream from related fields. For example, if one studied the concept of computer-supported learning, and only read material from the field of computer science, avoiding information from fields like pedagogy and psychology. The second alternative, is to narrow the field by redefining it, and make it narrower, but still keep the multiple perspective. For example, if one studied the concept of computer support learning, and decided to concentrate one’s work to systems for one particular kind of learning such as problem-based learning. The first type of specialisation seems to be less useful and even dangerous in that one misses the benefits of looking at things from another perspective. Even if the second type of specialisation narrows the field of interest, one keeps the possibility of looking at it from many points of view.

A scientist has many sources for acquiring relevant information: books, journals, e-mail, news-groups, abstracts, etc. To handle this manifold is a stress factor and consequently one reason why scientists come to a problematic working situation under the pressure of information overload. Most scientist, no matter which one of the above strategies they adopt, are using different tools to process the input stream, such as different sorting mechanisms, mechanisms to filter information and process of meta-information about the input. This collection of tools forms a personal information system. Also, it is common that these personal information systems contain some kind of classification system to help sort the information in the input stream according to relevance to the subject,

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15 When one is new in the field one knows little about everything, and with growing experience one tends to know more and more in a smaller area, and at last one knows everything about nothing…
urgency, etc. In such a personal information systems meta-information plays an important role similar to that of a larger information systems (discussed in the section above) to classify and filter information.

Our time is limited, which becomes particularly clear under the pressure of information overload. Consequently, things that we are able to postpone are being postponed in such situations. For that purpose a backlog are a common element in a personal information system. The information (objects) in a backlog is often characterised by relevance not so urgent, potential information value, something interesting to follow up, a new field of interest, and so on. In case of information overload it is common that all our limited time has been spent on the most urgent things, and no time is left to process the material on the backlog. This implies that the backlog keeps growing and tends to become impossible to manage. Sooner or later the moment comes when one must do something about the growing backlog. To do something in this case often means that one does not bother about some of the material, and just throws it away. Obviously this means that much of the material that is relevant, and of interest to one’s work is lost. Hence, to manage the backlog and the in-stream of information is an important part of a scientist’s working situation. Managing, both in the sense of deciding which material one should put on the backlog, and in the sense of what material one should take away from the backlog. The effect of time is one of the best and also one of the most frequently used methods of filtering information on the basis of relevance. Instead of taking all the new information into consideration, one can use a delaying strategy and be more time efficient. By waiting to see what other people think and report about the relevance and value of the material, one can avoid wasting time on material that will prove to be dead ends or contain incorrect information. Reviewing is one such filter mechanism that is being used in the scientific community. The use of time as a filtering mechanism, is limited to information with a long life-cycle, such as books, movies, and scientific documents. There are dangers with this method to cut the input streams; for example, if it is used on information with a short life-cycle or if no one or very few people are engaged in the filtering process, this can result in the loss of important information of high quality.

There are many other filtering mechanisms that one uses when managing the backlog. In fact, information filtering is a research area by itself, closely related to information retrieval. The main differences are that information filtering is a process to cut off all material with low information value in a dynamic in-stream of information, and that the information values matches a user’s or a group’s long-time goal.
All potential information (data) can be associated with an information value. Factors such as time since the creation, length, author, and accessibility (meta-information) are involved in the process to decide the information value. The accessibility factor is particularly interesting. Under the pressure of information overload, the factor of accessibility determines much of one’s decisions regarding the backlog. The accessibility of information is a matter of a cost, measured in the time or efforts needed to access the information related to the benefits it has for one’s own work. The cost depends on the physical accessibility, but there is a linguistic aspect, too. The purpose of reading may also work as a filtering mechanism – whether one reads a particular piece of material for a “short-term” consuming purpose, or if one reads it with a more long-term investment purpose. Wilson has found that people suffering under information overload, tend to read more information for short-term “consumption” reasons, and unfortunately do not have a long-term investment attitude to the reading or studying.

Wilson summarises the concept of information overloading and its consequences rather well, when he concludes that information overloading leads to a localism in the scientific community in several dimensions: temporal, linguistic and disciplinary. He also asks whether information overload actually is a problem. His answer is that – We should see overload not as a problem that might be solved, but rather a condition in which we unavoidably live (Wilson, 1993). I believe we have a great challenge in front of us, learning to live under these conditions in the future. We will need to develop methods and strategies that make it easier to live under constant “information overload”

Information seeking
Kuhlthau has been studying how library users comprehend the process of information seeking, in an attempt to empirically evaluate a theoretical model of the process of information seeking (Kuhltau, 1993). In this work, it is the connection between information seeking and theory of learning that is most interesting. Kuhlthau’s model of the process involves the user’s feelings, thoughts, and actions, and it consists of six stages: introduction, choice of task, exploring information seeking, focusing on the subject, information retrieving, and final information seeking. Kuhlthau found that, during the process the user’s feelings change from uncertainty and anxiety to a growing self-confidence. One of the basic conditions of successful information seeking is that the user focuses on the task or subject. It is important that the information system helps the user to focus on the intended subject and even helps the user to maintain the focus. It was found in
Kuhlthau’s study that the system of searching in libraries does not support this focusing process very well. My own reflection about this is that the problem is even worse on the WWW. Therefore, it is important that knowledge workers’ environments where WWW is a part contain tools that help the workers to maintain their focus.

Kuhlthau makes the conclusion that yesterday’s paradigm for information seeking (with a primary goal to find the “right” sources for information), must be exchanged with a new paradigm. The proposed paradigm – the uncertainty principle – is founded in results from the theory of learning and information science and has its focus on the use of information – for example to learn something. The six different aspects of the process of information seeking that Kuhlthau selects as important are: process, formulation, redundancy, attitude, prediction and interest.

Process – information seeking is a construction process and there are similarities with other learning processes.

Formulation – establishing and maintaining the focus of the subject, is important for a successful search process. The purpose of the establishing phase is to formulate the subject. Exploring information is very important in the process of establishing focus.

Redundancy – there is a dual relation between old (already known) and new information in a search process. Too much new information in the early stages of the search process is not so good, because it often leads to confusion and stress. On the other hand, too much old information in the early stages can result in the learner or user losing the focus and becoming tired of the task.

Attitude – the attitude to information alters through the process of information seeking, and mainly alternates between an open and curious (invitational) and a closed and restrictive (indicative) attitude (Kuhltau, 1993; Limberg, 1993). It is good for the outcome of the search process if the user can alternate between these two attitudes, adapting to the situation.

Prediction – like a learning process, the searching process is full of decisions and standpoints regarding further work; and, as in a learning process, there are decisions based on earlier experiences and knowledge.

Interest – the interest for a task grows after establishing a focus on the subject.

Is it necessary to know what one is searching for? According to Kuhlthau’s model of the process of information seeking, the answer is no (the first phase in the process of information seeking is to establish focus). Searching is
much a matter of strategy and ambition. Common for all strategies, is the need to get a feeling of how much information one has and when one has enough information, and hence can stop searching – some sort of confirmation. This becomes even more clear in a working environment where information seeking is a central element. For my purpose, it would be useful to identify different levels of ambition or purposes for the process of information seeking, such as to find all information, to find as much information as possible within some given restrictions, or to just find some information.

Information retrieval interaction

When discussing information systems it is quite natural to come up with questions that have to do with the search space and how it is constituted. It is also quite natural to discuss questions and problems that concern navigation and orientation. “Information retrieval interaction implies the study of interactive communication and seeking processes that occur during the retrieval of information by involving all the major participants – or actors – in these processes. This implies the user, with his or her desire for information, the intermediary (interface mechanism), and the ir system.”, (Ingwersen, 1994).

According to Ingwersen, these questions have a lot to do with the process of information retrieval interaction, too. Ingwersen stresses that there are three main elements involved in the domain of information retrieval interaction: the user, the IR-system, and the interface mechanism between the IR-system (with its objects and its settings such as the database structure, retrieval techniques, and rules for indexing) and the user.

The distinctions between the rationalistic approach and the human-related approach are visible in this domain, too. There are (at least) three different approaches within information retrieval interaction. Two of them are rationalistic: the system-driven approach and the document-driven approach. The third one, the user-oriented school is human-related. Besides the involvement of users in the research there is an interesting difference between these approaches in the way that they match the search result with the user query. The rationalistic approach uses best-match algorithms, whereas the human-related approach assumes that the users are interested only in an exact match between the query and the search result. Of course, this difference has implications for the methods used in analysing queries and potential information. The user-oriented school adopts analysing methods based on Boolean logic, to get the exact meaning of the query and of the stored information, for the matching procedure. Both of the
rationalistic approaches adopt the idea that one can grade how well a particular piece of information matches a query. Even though both rationalistic approaches use the same kind of matching algorithms, they differ in the theoretical basis for the analysis of stored material and queries. I believe that the statistic approach and the linguistic approach are better names for the two rationalistic approaches – these names say more about the kind of theories the analysing phase is based on. In a purpose to match stored material against requests, the system-driven approach uses analyses and methods based on statistics, like the vector-space methods, in which a word-document matrix is used to represent the information space. The elements in the matrix are word-frequencies, and each document is represented by a vector in this information space. For the matching procedure, the vector-space model (the cosine formula) is most commonly used, but (Foltz & Dumais, 1992) discuss the LSI method, which is an extension of the vector-space model by using singular-value decomposition. The document-driven approach uses linguistic analyses for the same purpose. Texts and queries are analysed morphologically, syntactically, and semantically, and the information space is commonly represented by some sort of semantic net.

Regardless of which approach the information retrieval system is based on, the fluctuation in the value of the information or the uncertainty about the information value of a specific material, causes great problems for the information retrieval process. Most of the problems have to do with the process of mapping user desires against the basis of stored material, to select relevant material for delivery. I think that, part of the explanation for this problematic situation is the assumption that the user has a need to get all the relevant material. I believe, however, that the purpose of information retrieval will become more and more a matter of satisfaction, where the users have no or little desire to actually get all the relevant information. If this is the right picture of the future, it has consequences for the design of information retrieval systems: it will be a future where information browsing and fuzzy queries are natural parts of the information retrieval systems.

Information science and knowledge work

Many attempts are now being made to use the Internet, and the huge, chaotic, and anarchistic information-system of the WWW, for the purposes of work and education. These attempts increase the relevance of information science. I think that there are mainly two ways that information science can contribute to interactive learning environments aimed to meet future requirements.
Chapter 4 – Perspectives on Learning and Knowledge

The first way is that insights from a science studying information and information systems, give a wider view on learning and knowledge. For example:

- the human-related focus on cognitive aspects in the study of information and information systems;
- the way the human-related approaches discuss how data, information and knowledge are related to each other in terms of potential information, information value related to individuals, state of knowledge, state of uncertainty, and problem space;
- the role of information as a bridge or a medium in the process of cognitive communication of states of knowledge.

The second way in which information science can contribute is the insights into what the main problems are in large information systems, and how one should act to meet these problems. The problems that I have thought of as important to investigate can be divided into three categories: managing and designing large information systems, the process of information seeking and retrieval, and information overload. These categories also indicate the necessity of tools that make it easier for a learner to study in such an environment.

To illuminate some of the aspects of information science that are useful and also to illustrate the need for tools aimed at supporting the learners studying in a learning environment where information seeking is central, I will sketch a number of scenarios. All scenarios have in common the use of a large computerised information system in the learning or working environment. This information system holds both material (text, pictures, etc.) and information about non-digital material (like a traditional information system in a library).

**Scenario 1:** Imagine a situation where you are interested in computers, and you want to learn more about computers. You start using the WWW as a learning environment and find some good sites to look at, with information related to computers. The feeling you get is that the area of computers is large: programming, design, hardware, etc. You also feel that it is impossible to study all of these sub-areas – what do you want to study?

Here Kuhlthau’s model for information seeking and her uncertainty principle with all its elements has much to say (Kuhlthau, 1993; Limberg, 1993). The fundamental assumption in Kuhlthau’s model is that information seeking is a construction process. She makes a comparison with the process of learning. She also thinks that it is important for the outcome of the search process, that
the information seeker has formulated a goal to focus on. For the purpose of establishing a focus, the exploration of information plays an important role. The learning or working environment must provide support for the learner to explore the information space, in the purpose of getting a goal to focus on. This support will help the learner to build up a personal model of understanding of the subject. One of the basic elements in the phenomenological approach is the question of motivation that has a functional relation to the outcome of the learning process. Kuhlthau’s uncertainty principle for information seeking has a similar element – interest; she has found in her studies that interest for the task increases after having established a focus.

Scenario 2: Imagine a situation where you have a goal to learn object-oriented programming and you decide to register on your company’s internal course in object-oriented programming. The course is based on self study, and the company uses the WWW to distribute the course material. The company gets several positive effects by doing this. Apart from the economic benefits, it is believed that if one uses the WWW for this purpose, the learners will get access to a huge amount of relevant information for the course. Some course administrator prepares reading instructions, makes pages with references to relevant links, etc. You start to work with the course material, reading, doing exercises and so on. After a while you discover how easy it is to get more information about object-oriented programming from the “web”. You start exploring the “web”. The next discovery you make is that the “web” consists of huge amounts of material that you are interested in. Both material with relevance to the course and material that you are just interested in for some other reason. The questions you ask are: how should I manage this situation, what is good material, what must I read, what should I not read? The whole situation starts to confuse you.

Wilson discusses and describes information overload from a scientist’s situation, how they react to the pressure of information overload. The conclusion from this discussion is that information overload is a condition in which we unavoidably live, and there is a need for good tools that make it easier to live under these conditions. In the scenarios above, the learner has reached the same condition as the scientist who has come under the pressure of information overload.

In order to handle the pressure of information overload one has to cut back the information inflow in some way, or alternatively decrease the gap between what one wants do to and what one can do with the information by increasing what one is able to do. Both strategies are rather difficult and one needs good support from the working environment. According to Wilson,
there are two ways that scientists usually react to information overload: by specialisation and by satisficing. Both processes serve as a sort of mechanism for cutting down the amount of material to use or study. I believe that a conceivable side-effect of these processes, are certain changes in the scientist’s understanding of the subject, in the scientist’s state of knowledge. In other words, the scientist has learned something about the subject in the very process of specialisation or satisficing. If one examines these processes more closely, they are seen to involve several decisions based on some comprehension about the value that a specific material has.

Scenario 3: Imagine a situation as in the previous scenario, with the same goal, to learn object-oriented programming. You have studied the subject for a while and you are starting to feel rather comfortable with your situation, but there is one thing that worries you. You have a feeling that you master the area of object-oriented programming. How can you be sure that you have not missed something important, that you don’t have any blind spots?

It is important to know what one knows in all kinds of learning situations. The main reason for this is the generous measure of freedom that the learner has; freedom to make decisions about what to read, etc. The need for tools in this scenario, are tools that help the learner to get a picture of the learner’s own state of knowledge and its relation to “what there is to know”. I see a possibility to adopt methods from informetrics. Methods that are traditionally used on large information spaces to discover and explore characteristics of information, organisation, and distribution can be transformed into handy tools usable on smaller information spaces like the personal information system. In this scenario, too, Kuhlthau’s model for the information seeking process is instructive, for example reminding us about the importance of keeping focused. Formulation of a goal or focus for one’s studies is important, but it is equally important that the learner gets support for the efforts to keep the focus, during the whole process.

Scenario 4: Suppose that you want to evaluate or judge a number of different approaches or models for computer-supported learning in a quantitative manner, for example how efficient your system is in delivering desired information to the learners.

The matter of efficiency of an information system, is one of the main questions in the rationalistic approach to information science. Of course, when one starts to think in terms of the user’s experience of the system, the human-related approaches are relevant, too. I believe that the information management and information retrieval system design, are the sub-domains that have the most to contribute. Especially the methods they use to analyse the use of information systems, for example the concepts of recall factor and
precision. Efficiency also depends on the user’s experience of the system. The area of information retrieval system design uses well-known design and evaluation methods from other areas such as computer science.

To summarise, the most useful elements from the area of information science for a model or system that supports learning are:

- the connection between the information seeking process and the learning process Kuhltau makes, viewing both as construction processes;
- the view that the human-related approaches have on data, information, and knowledge, which implies that one takes cognitive aspects into account in the discussion of these three concepts and their role in an information system;
- the insight in the situation of information overload and the dimension of time and uncertainty of information as a natural part in a learning situation of tomorrow and the consequences that has for the learners’ working situation – consequences which imply a need for tools that will make it easier for the learners to study in learning environments suitable for the future educational situation.

8. Key concepts for new learning environments

To view a learning situation as an information system is fruitful in many respects. Mapping a learning situation with teachers and learners, on models from information science, gives a picture in which the left side of the figure on page 57 is the teacher-side, and the right side the learner-side of the learning situation. This figure can be used to highlight some of the differences between a traditional approach to learning and knowledge and the phenomenological approach.

I believe that the human-related approach of information science stands for an attitude that can also be found in the phenomenological approach to learning, whereas the rationalistic approach is more related to the traditional approach to learning and knowledge. To a great extent, differences between the phenomenological approach and more traditional approaches, have to do with their view on knowledge. To the phenomenological approach understanding is central, and learning is viewed as changes in the learner’s understanding. To the traditional approach knowledge is a matter of right or

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16 The recall factor is the proportion of all relevant documents that are actually retrieved. Precision factor is the proportion of retrieved set of documents that is actually relevant (Belkin & Croft, 1992).
wrong, and learning has to do with memorising or receiving the right facts and the right procedures to perform tasks. Therefore, it is possible to reduce learning to communication or transfer of character strings. This is just like how the rationalistic approach to information science reduces information to the level of characters, and the transfer of characters. Another basic difference is the view on the learner’s role. In the traditional approach, learners are viewed as rather passive receivers of knowledge, but in the phenomenological approach learners are viewed as active, forming their own knowledge. This latter view on learning and knowledge matches rather well with the human-related approach and its view of information system: information is something that arises when a person (recipient) is working with data or potential information, and which affects and transforms the recipient’s state of knowledge.

The view on knowledge, together with the view on learning, form a basis for learning environments – determining which methods and tools that should be provided. I will use a number of key-concepts to describe the primary result from this chapter, which in short is a wider perspective of learning and knowledge.

**Knowledge workers** – scientists and researchers actually work with knowledge. In the kind working situation that most scientists have, producing, consuming and processing knowledge are manifest elements. Also, in my experience from the scientific world, scientists are driven to a high degree by internal factors of motivation and relevance in their work. The phenomenological approach to learning, with the learners’ understanding in focus, makes the learner’s working situation similar to the scientist’s working situation. One of the greatest benefits with adapting the learning situation for education on a lower level, to a scientist’s working situation, is the goal-oriented process of learning that characterises a scientist’s working situation.

**Understanding** – there are different kinds of knowledge, as illustrated by the distinction between knowing how and knowing that. Knowledge is more: it is also a question of understandings or conceptions of phenomenon. With this widened view on knowledge, it becomes necessary to change from a quantitative approach on judging knowledge to a qualitative approach. Such a qualitative approach implies a view where a person who can reproduce the data or material without understanding the meaning of it, has a low level of knowledge, whereas a person who has grasped the meaning of the material, has a higher level of knowledge.
**Learning is a generative process** – there are many perspectives on knowledge, and consequently, there are many views on learning, too. Among all ideas on learning, the idea that learning is a process is generally accepted. On the other hand, there is no generally accepted idea about the characteristics of the learning process. One idea that can be identified among several learning theories (Kearsley, 1994) is to view the learning process as a generative process – generative in the sense that one can see the function of the learning process as being a way to weave or elaborate new knowledge together with existing knowledge (Wittrock, 1974).

**Confirmation** – to have an idea of what one knows and what one does not know, is a question of confirmation. The possibility for the learners to confirm their state of knowledge plays an important role in every kind of learning situation. Confirmation of the state of knowledge can be done in many ways, from regular examinations which are used in traditional education, to methods in which learners have more control over the process, like self-assessments. I think that the individual’s ability to interpret and judge information can play an important role, and that it is possible by using techniques for user modelling and visualisation, to produce images (information) that in some sense mirror a learner’s state of knowledge; and that these images have the potential to be used by the learners to assess their own knowledge.

**Active learners** – there are many aspects of the role that learners can take in a learning situation; the degree of activity is one. The phenomenological research on how we learn has many interesting results concerning this. For example, the functional relation between the level of processing and the level of outcome from the learning process, implies that a learner with a depth-directed style tends to actively process the study material. These learners actively set up goals for their studies and in an active way pursue these goals by active processing of the material, active searching for relevant information, and active collecting of information. Moreover, motivation and relevance are factors that really affect the level of processing, therefore it is important that the learning environment encourages the learners to be motivated by internal factors.

**Focus** – to know what one wants, and to be able to formulate one’s interest, are both questions of focus. Kuhlthau has shown with her research on the process of information seeking, that focus has a great impact on the outcome of the process. For learners studying in a learning environment based on exploring and information searching, with a great measure of freedom, focus is important. This means that learners need support to establish focus and keep them focused during the process of learning.
Communication – one important factor of learning is to learn from one’s own experience, but also learning from others’ experience is important. I believe that in many learning situations most of the people involved, both learners and educators will benefit from a non-competitive mentality. I have a hypothesis, that actively processing how other people have worked with a topic has a positive effect on one’s own outcome of the learning. I also believe that to communicate to others the way one has worked with the topic – to act like a teacher – is beneficial for one’s own learning outcome.

Searching – the wish to learn is, I believe, one of our strongest driving forces. In some sense, it is possible to interpret the above statement, as “one of our strongest driving forces is the wish to search for new information”. I think it is a good idea to base a learning environment for the information and knowledge society on information seeking; at least it should be an important element. In the phenomenological approach the learner’s freedom is central; freedom to construct and form knowledge in a way that suits each and everyone, and freedom in the sense that the learners have control over the learning environment. For example, the learners are given the freedom to process the topic in a way that suits them, and the learners have the opportunity to actively choose what tools to use at each moment of the learning process. With this in mind, many of these tools must have the basis in exploring and information-seeking.

Navigation – to travel from one place to another involves navigation, making decisions about how to proceed. In the context of learning, the decisions are about what one should focus on or study next. Like a sailor needs tools such as a compass and nautical charts to navigate across the oceans, learners (which study in a learning environment based on an information searching metaphor) need tools to navigate in the information space. Many human activities are guided by our ability to evaluate and interpret information. This must be taken into account in a learning environment, and in the design of tools that support the learners in their decision making, especially their ability to interpret visual and spatial information.

Orientation – to know where one is, is to be orientated. In its literal meaning, orientation is related to geography. In a learning situation, orientation is related to more abstract structures such as data, information and knowledge. To be oriented in a learning situation, is in some sense to know what one knows, and also to know what one does not know, and perhaps also to know what others know, and do not know. To be conscious of one’s own state of knowledge plays an important role for decisions about further actions (compare Confirmation above). In learning environments
based on exploration and searching, the learner travels—metaphorically speaking—in an information landscape, with the purpose to find or search for relevant and interesting information; here orientation regains some of its usual meaning.

**Interpretation**—our ability to interpret symbolic information is exercised in many situations in our daily life. Road signs, warning signs, and graphical user interfaces (GUI) of computer systems, are some examples. Also when we communicate with other people, synchronous or asynchronous, and independent of the medium, our interpretative ability is utilised. E.g. facial expressions, CAPITAL LETTERS or other typographic variation such as **bold** face or *underlining* in a text give us a hint of how our communication partners feel, understand what we are saying, and so on.

When perceiving an image, there is much information that can be extracted from it. On one hand, there is information that can be read directly off the image, for example the facial expressions in Figure 12, where one shows happiness and one sadness. On the other hand, there is much information that can be extracted, but not as directly as in the case with facial expressions. For example, how the creator of a picture felt when creating it, what the messages are, that the creator wants to communicate with the picture. Information of this kind is almost infinite. How hard it is to extract information from a picture depends on many factors, for example, whether the motive is abstract or concrete, whether the pictorial language used by the producer is well-known to the perceiver, etc.

![Facial expressions](image)

*Figure 12. Facial expressions.*

We have almost an identical situation when reading a text or listening to music: there is very much information in the texts and music about the authors/composer and their values, situation, etc. The major difference is in the kind of symbolic language that creators use and the interpreter has to master.
**Representation** – to capture and formulate on some abstract level an individual’s interests, goals (both short-term and long-term), state of knowledge, and also to capture the meaning or the value of information, are all matters of representation. There are many ways in which objects (data, information and knowledge) can be represented, from a linguistic level with semantic and syntax to a statistical level with for example word-frequencies. The purpose of representations in a computer-based learning environment is manifold. For example, traditionally the representation of a learner’s state of knowledge (user models) is used to control the learning situation, but it is also possible to use this kind of representation to construct images (maps), which can be used to guide, motivate, etc., the learners. The introduction of the phenomenological approach as a basis for computer-based learning environments gives rise to new needs for representing qualitatively different levels of understanding. Then, it becomes important to be able to produce accurate maps of learners’ state of knowledge.

**Organisation** – to manage and process the information flow and information space to make them easier to handle, is largely a matter of organisation. Typically, we create and use some sort of personal information system to manage the information flow, and in some sense to manage the information overload. The benefit of such a personal information system is that it unburdens the users by releasing capacity to more constructive activities. I believe, however, that learners have much more to benefit from work related to organisation (such as organising, re-organising, structuring and re-structuring). This kind of work also helps to keep the learners active, with positive effects for the outcome of the learning process.

**Meta-information** – information about data, information, and knowledge plays an important role in a learning environment designed for the education of tomorrow:

- much of the work with organisation and management of information, is based on meta-information;
- meta-information has the potential to serve the learner with an abstracted and structural view of a topic; for example how different sub-areas are related, which people are close to the centre of the topic, etc.;
- meta-information is used to make it easier to match users’ desires against stored material in information systems;
- to view, work out, and actively process meta-information can serve to support the learners in the construction process that learning seems to be.
In other words, much of the work that a knowledge worker does, is focused upon meta-information. It is possible to identify several kinds of meta-information, for example: length of the text, language used, how the different areas of the topic are connected to each other. Knowledge about what one knows is also a kind of meta-information or meta-knowledge, associated with confirmation and assessment. Another interesting question is the relationship between the processing of meta-information, and the concept of level of processing. Even though meta-information is commonly viewed as rather superficial information (references, length, language, etc.), by working with it actively a deep understanding of the topic can be reached. There is also reason to believe that more sophisticated types of meta-information will become more and more important and common in the information society (Negroponte, 1995).

To conclude; all of the disciplines that are discussed in this chapter have more or less concrete notions, problems, and solutions, to contribute to the design of tomorrow’s learning environments. The main contributions are summarised in the above list of concepts and characteristics of a learning environment. These are the concepts I think are the most important for a learning environment to succeed in fulfilling the requirements that the new educational situation of the information society sets. In the next chapter a pedagogical framework for the educational requirements in the knowledge society is proposed. The Knowledge Worker approach has its base mainly in the phenomenological ideas on knowledge and learning combined with ideas and results from the area of information science.