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KNOWLEDGE-BASED INFORMATION TRANSFER AND MANAGEMENT, AN INFORMATION SCIENCE CONTRIBUTION TOWARDS TECHNOLOGY TRANSFER

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1. THE TRANSFORMATION OF KNOWLEDGE INTO INFORMATION

From the perspective of information science, effective technology transfer depends on a sufficient supply of information. We hold that - according to the well accepted distinction between invention and innovation[1] - knowledge which has been produced and which is, at least in principle, either publicly available on the market or is produced for closed circles, e.g. in organizational environments, must be transformed into information. Technology transfer is thus reduced to the transformation of knowledge into information. In this chapter we would like to discuss this systematic approach of information science somewhat more.

Information problems can be subsumed under the generic question of how knowledge can be transformed in such a way that it is useful in concrete (critical) situations. "Transformation" is not to be understood as a mere transferral process but as a highly differentiated bundle of knowledge/information activities (cf. Fig. 1) which, altogether, constitute a major part of information science methodology.

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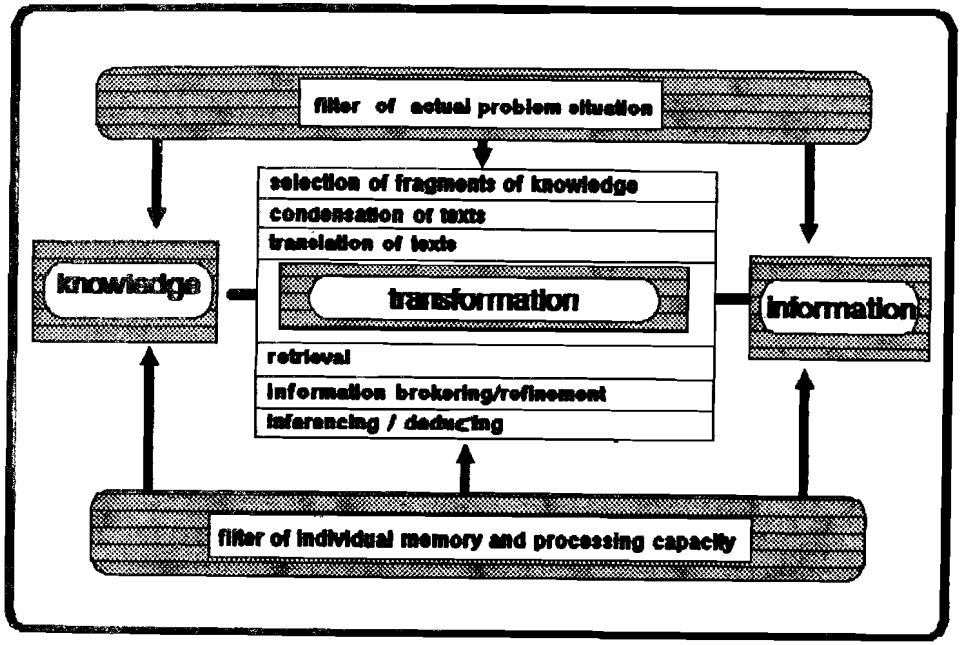
[1] Invention refers to the domain of knowledge or ideas (what is really new), whereas innovation means the transformation of a new idea (an invention) into a new product or a new procedure.

Figure 1. EXAMPLES OF TRANSFORMATIONAL PROCESSES



As one can imagine, the transformation of knowledge into information is a highly delicate and user-dependent process. What is new for a student may be old hat for a scientist, what is of strategical value for a trade unionist may be useless for an industry manager. Information processing is not a neutral matter but a functional one, functional with respect to anticipated or concretely analyzed users' needs and situational requirements. Therefore the methods of information transformation are equally influenced/filtered by situational and cognitive factors (cf. Fig. 1)[2].

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[2] From the point of view of information management, organizational factors such as hierarchical structures, organizational objectives, and task descriptions function as additional filters for the transformation processes.

We call these bits of knowledge which are needed, e.g., for decision making or problem solving, information. It may be that in some cases, information only delivers knowledge in a different shape (for example, as condensates or translations), or reactivates currently forgotten knowledge; in other cases information delivers new knowledge - new not only with respect to the user but also new in an absolute sense: transformation, for example, inferencing, may operate on old knowledge and result in new knowledge.

Information, within this information science framework, plays an active or innovative part, whereas knowledge (that of single persons, of organizations, or of society in general) is the basic resource (or the memory) which people need to solve problems in general. Information adds value to the existing knowledge of people or, at least, activates existing, but passive knowledge.

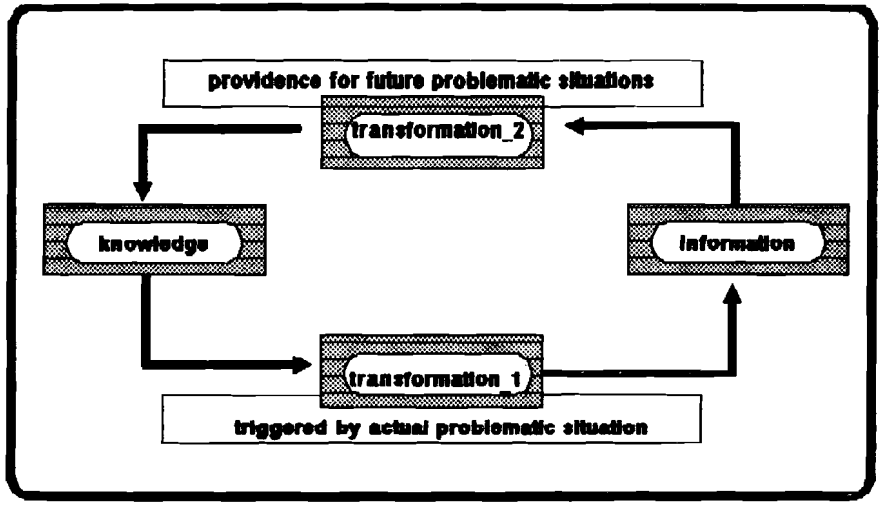

Figure 2. THE DOUBLE PROCESS OF TRANSFORMATION

Information can be forgotten after being used, but in most cases does not lose its value through use; information can be kept (stored in memory) as additional knowledge and can thus be "recycled" as information in other critical situations at later dates. As one can see from Fig. 2, the relation structure between knowledge and information can be understood as a double transformation process, whereby transformation_2 (as a storage or build up process) can be interpreted in part as the reverse process of transformation_1.

Information must be acquired with appropriate methods on the occasion of special, mostly unique situations and is not objectively available on the market. If one accepts this argument, then the term "information processing" does not make much sense,

because what will be processed is knowledge in its data form, not information. Information is the result of processing. Therefore we prefer - at least in German - to use the term "Informationserarbeitung" (information acquiring) instead of the more general term "Informationsverarbeitung" (information processing)[3]. Information processing in this sense refers to methods by which the information which has been acquired as potentially relevant (relevance information) can be transformed into so called performance information which will actually be used in the critical situation (cf. Fig. 3).

The steps in the general transformation process (as indicated in the oval boxes in Fig. 3) are constitutive for the different kinds of knowledge work (as indicated by the square boxes in Fig. 3), in particular for the development of methods for the production of knowledge (by improving word processors and editors), for the distribution of knowledge (electronic publishing and electronic text/document delivery), for the representation of knowledge (all kinds of representation languages), for the management of knowledge (natural language access to data bases, knowledge bases), and for the acquiring and processing of information. Even if these components can be treated independently they are considered as functional units keyed to the main purpose: the use of performance information.

[3] To apply this terminological distinction consistently is somewhat tedious, therefore we shall use the familiar term "information processing" but would like to have it understood with the implications mentioned above.

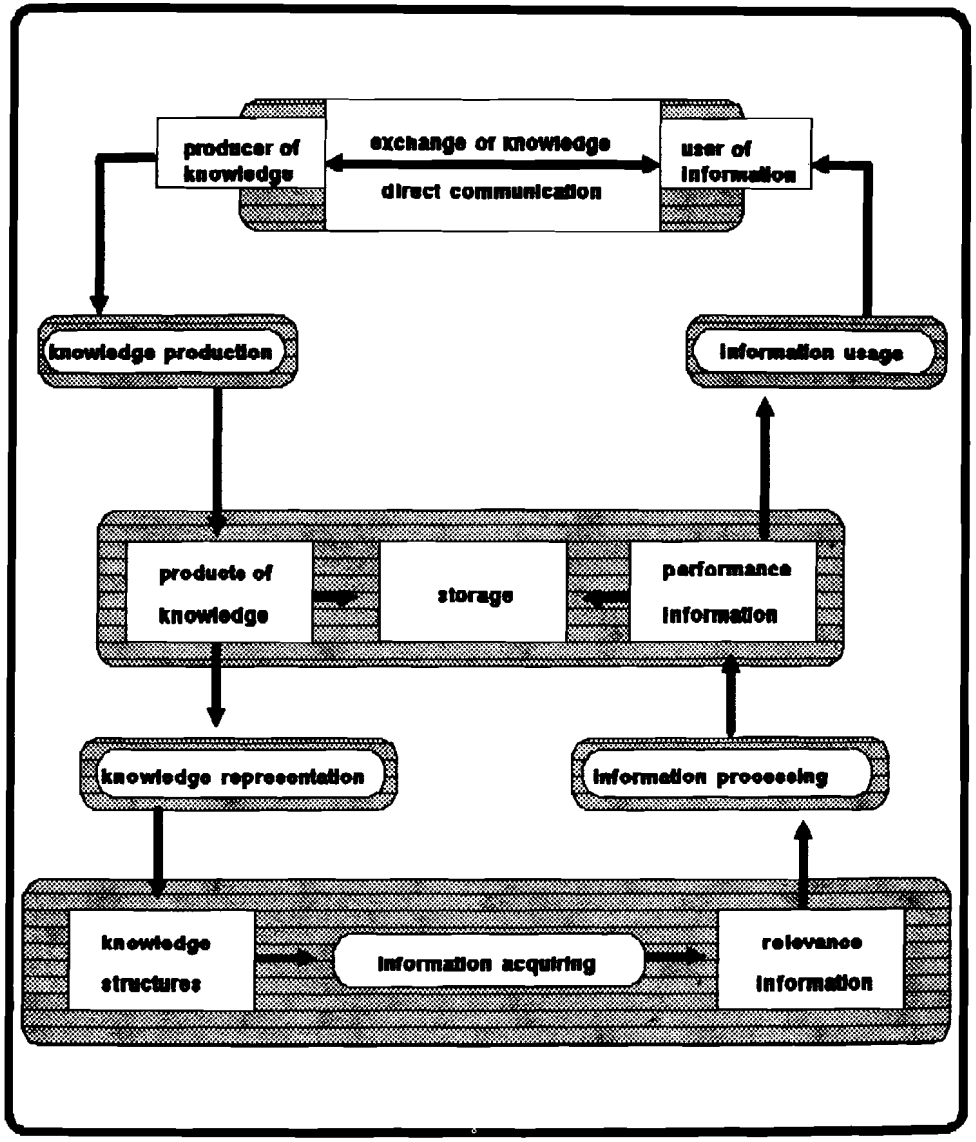

Figure 3. STEPS IN THE PROCESS OF THE TRANSFORMATION OF KNOWLEDGE INTO INFORMATION

2. INFORMATION SCIENCE CURRICULUM WITH EMPHASIS ON INFORMATION TRANSFER AND INFORMATION MANAGEMENT

In the following we would like to concentrate on the curricular consequences of this information science understanding as they have been realized in the post-graduate course for Information Science at the University of Constance[4]. According to the systematic approach described above, the programme emphasizes the two fields of information transfer and information management

Information science at the University of Constance started its work as of 1980. Since then, we have built up a research group that conducts projects mainly financed by public sponsors[5], runs a four semester post-graduate course in information science and a modern, well-equipped, mainly micro-computer based EDP-laboratory. Let me briefly describe the structure of the programme. First, some statistical information about the students of our curriculum follows:

As one can see from the statistics (cf. Tab. 1) we only accept a very limited number of students (about 25 students beginning in the fall term), who must be highly qualified in their first field of study. The term "post-graduate" does not mean - as is sometimes the case in American post-graduate courses - that the students already have academic or professional experience in information science or practice. Our students at the beginning are in general real freshmen in information science and have academic backgrounds from almost all fields (cf. Tab. 2). Information science at the University of Constance is a genuine scientific melting pot, as is the case in professional information environments as well.

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[4] Information science in West-Germany on a university level is still, and possibly will always be, a small discipline. Full curricula in information science are offered only at four locations, at the universities of Berlin, Düsseldorf, Saarbrücken, and Constance. But, of course, there is much more information science research and teaching going on in West-Germany: for example, almost every computer science department deals with information science topics, and departments of psychology, linguistics, and economics are increasingly coming to realize the importance of information processing from psychological, linguistic, and economic points of view, respectively; cf. Kuhlen 1986b.

[5] Among our current projects are:

Topic/Topographic - a knowledge-based text analysis system for the purpose of text condensation and with a graphically supported retrieval and (knowledge and text structure) presentation interface, cf. Kuhlen 1984; Hahn/Reimer 1986; Thiel/Hammwöhner 1985.

NisVer - Knowledge-based information processing for the support of administration in the domain of "existence funding", cf. Kuhlen 1986a.

CurMod - Curricular models for information professions in organizational environments, cf. Kuhlen 1985.

	1st year WS82/83	2nd year WS82/84	3rd year WS84/85	4th year WS85/86
total	16	22	22	37
Constance	11	8	9	12
other universities	5	14	13	25

Table 1. Students Statistics

	1st year WS82/83 (16)	2nd year WS83/84 (21) *	3rd year WS84/85 (28) **	4th year WS85/86 (34)
mathematics, physics computer science	6	6	4	10
biology, chemistry	2	–	2	2
administration science, law, economics	5	10	9	10
social sciences	3	2	1	5
other disciplines				
psychology		1	1	
medicine		1		
library science		1		
history			1	
French literature			1	
German literature				4
architecture				1
engineering (machine)				1
geography				1

Table 2. Students Academic Background
(* 1 Student unidentified, ** 2 students unidentified)

We hold that the combination of solid knowledge in a certain scientific or professional field and of information science methodology is extremely helpful, if not necessary, to meet the actual and future professional needs of information transfer specialists and information managers. Information service can hardly be accepted without domain-specific knowledge and experience. And the same goes for information management, which should be based on profound knowledge of organizational and economic theory acquired in a first field of graduate study.

It may be thought that there is a danger in this constellation that our students are too old as job beginners. An average program of graduate study ending with a degree in Germany lasts in general about 5 years, and with the additional 2 years in information science, these students have indeed a double academic background and are at least 27 years old. So far, however, this has not turned out to be a disadvantage; none of our students has problems finding an appropriate job. Indeed we have problems keeping them off the market until they have finished their degree. The demand for well-trained or even only partially-trained people in the field of information and communication technology is steadily increasing in countries like West-Germany.

Let me briefly describe the two major fields we concentrate on.

2.1 INFORMATION TRANSFER (COUNSELLING/BROKERING)

Information transfer ("Informationsvermittlung") is the professional usage and tranformation of resources and products of the information market for the purpose of satisfying information needs. The increasing computerization of information services, originally designed to assist end-users, complicates information work and consequently increases the demand for professional information people. Information transfer plays an important role among the different information activities, as can be seen from Fig. 4.

The information transfer specialist ("Informationsvermittler") ascertains the exact information requirements of the end-user and selects the relevant information from the range of information systems and other information resources and passes it on to the user in a comprehensible and usable form[6] (cf. Fig. 4).

[6] For a more detailed description of the duties of an information transfer specialist, cf Vogel 1985, 1986; Kuhlen 1985.

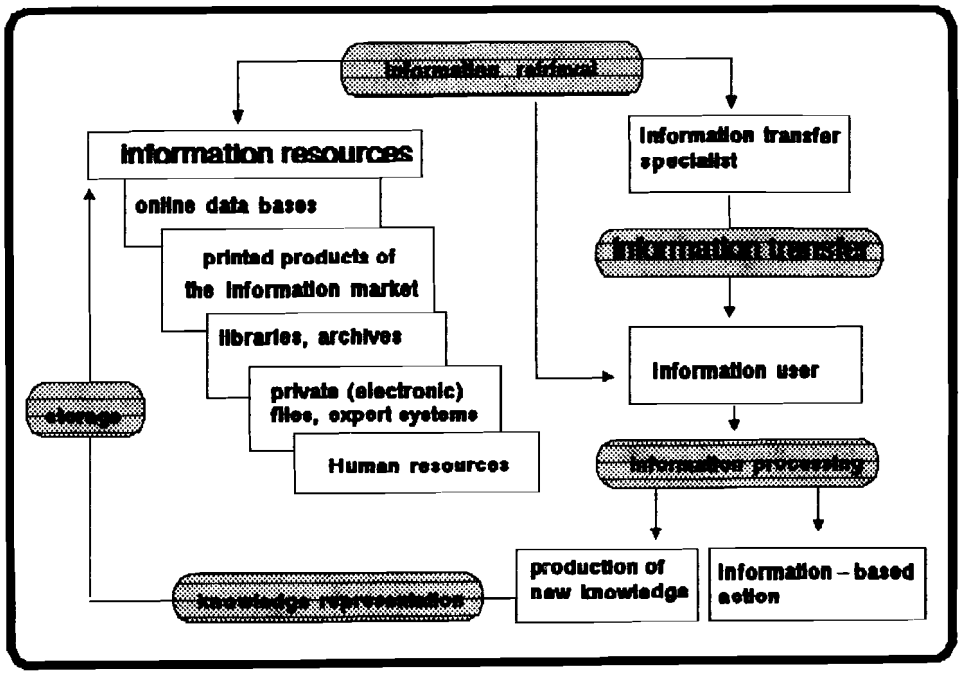

Figure 4. Information Transfer

2.2 INFORMATION MANAGEMENT

Information management is the organization of information in an organizational environment. It is becoming increasingly important for institutions of all kinds (both public organizations and private enterprises) to professionally organize the existing supply of know-how and technology. Information is thus comparable to other resources, such as people, finance, raw material. The situation of information management which can be understood as the coordination of internal and external information resources, is shown in Fig. 5.

In accordance with professional demands, we believe that information transfer specialists and managers, respectively, should have the qualification profiles which are shown in Tab. 3. To acquire such a profile and to be well prepared for the demands of the job market we require[7] that our students take the courses shown in Tab. 4.

[7] This program can be enriched by extra-curricular courses offered by other departments (psychology, linguistics, social sciences, economics, etc.). Credit is required for only ten courses (seven courses from the three sections described in Tab. 4, one project course and two courses of the students' own choice).

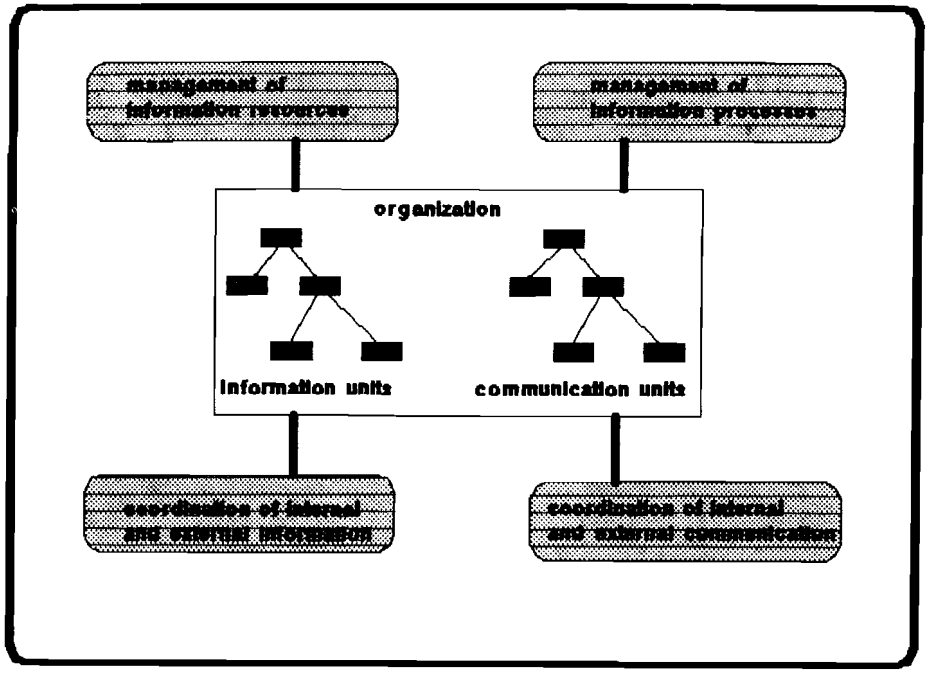

Figure 5. Information Management as Coordination of Information Resources and Processes (Communication)

3. HARDWARE AND SOFTWARE EQUIPMENT

Information science at the University of Constance has concentrated, from the very beginning, on experimental work both in study and research. This means that information and communication technology has played an important role.

Although the information science department has local access to the main frame computer of the campus computer center (an IBM-compatible BASF-computer) - and this access is intensively used by the students in programming courses and for editing their own papers - we have decided from the beginning to become computationally independent. Fig. 6 gives an overview over the present status of our laboratories.

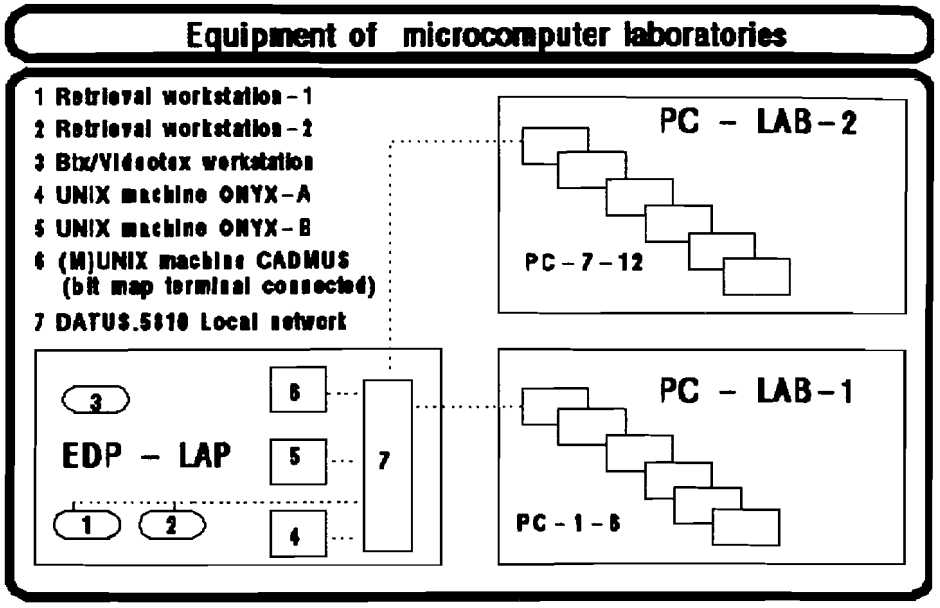

Figure 6. Microcomputer Equipment of the Information Science Department of the University of Constance

As a general objective, our computer equipment had to satisfy the needs of research project members, of people involved in training, and of adminstrative staff. It might well be possible today to find a hardware solution which would completely concentrate on PCs. In 1981/82, when we started to build up our laboratory, the situation was somewhat different, and therefore we have microcomputers available on two levels, either time-sharing microcomputers on a Unix-basis (ONYX- and CADMUS-machines) and personal computers (mainly MS-DOS-based) usable as stand alone machines but also connected by a local network (DATUS). Everybody can take advantage of the whole gamut of technology available (and each faculty member has either a terminal or a PC or both on his/her desk). The DATUS-net has its own DATUS-P-exit, therefore retrieval in public data bases and the usage of other telecommunication facilities (bulletin boards, nation- and worldwide mail- and message systems) is possible from each single desk and is becoming increasingly used and useful.

Qualification profiles for information transfer specialists and information managers (B = Basic I = Intensive)

Field of qualification	Subject	Information transfer	Information management
I. Methods of investigation / analysis / design implementation	– techniques of investigation, (interview, inquiry, obervation, experiment)	B	I
	– techniques of analysis and design (descriptive and predictive statistics)	B	I
	– techniques of analysis and design (system analysis, system design)	B	I
	– techniques of organizational implementation	B	I
II. Methodical and technical fundamentals of information systems	– database methods	I	B
	– methods of structured programming	B	B
	– information linguistics	B	B
III. Use of information systems	– information services	I	B
	– information retrieval systems	I	B
	– intelligent information systems	B	I
	– office information and communication systems	B	I
IV. Content analysis/ knowledge representation	– techniques of intellectual content analysis (indexing and abstracting rules, documentation languages) knowledge representation languages and inferencing techniques	I	B

Table 3.1 Qualification Profiles of Information Transfer Specialists and Information Managers

Qualification profiles for information transfer specialists and information managers (B = Basic I = Intensive)

Field of qualification	Subject	Information transfer	Information management
V. Information presentation	– methods of information presentation and refinement (graphics, texts)	I	B
VI. Psychological and social conditions of information processing	– psychological and cognitive aspects	B	I
	– social and communicative aspects	I	I
	– information and society	B	B
	– information market	I	I
VII. Organizational conditions of information processing	– profitability of information/ cost – benefit analysis	I	I
	– organizational and legal aspects	I	I
	– business mangement science	B	I
	– programme and fincance planning	B	I
	– personell and organizational development	B	I

Table 3.2 Qualification Profiles for Information Transfer Specialists and Information Managers

Compulsory courses in the information science curriculum at the University of Constance

(hours per week)

	Information Transfer	Information Management
A Methodic fundamentals		
1. Techniques of system analysis, system design and implementation	–	4
2. Methods of structured programming	4	4
3. Information and communication technologies	2	4
4. Database methods	4	–
5. Information linguistics	2	2
B Information systems		
1. Information services	2	–
2. Information retrieval systems	6	4
3. Intelligent information systems	–	2
4. Office information and communication systems	–	4
5. Techniques of intellectual analysis	2	2
6. Methods of information presentation	2	–
C Social context		
1. Psychological and social aspects of information processing	4	4
2. Information and society	2	2
3. Information market	2	2
4. Profitability/economics of information	2	2
5. Organizational and legal aspects of information processing	2	2

Table 4. Compulsory Courses in the Information Science Curriculum at the University of Constance

4. A FRAMEWORK FOR INFORMATION RETRIEVAL ACTIVITIES

As mentioned above, the availability of performance information (adequate pieces of knowledge) is an essential requirement for successful technology transfer. Although it is well-known that informal ways of information work, such as visiting conferences, contacting friends or colleagues, reading a few, but supposedly central journals, are often more intensively chosen than professional formal methods of information retrieval, it is expected that, with the advent of integrated workstations, the situation will rapidly change. There are good reasons for the assumption that previous solutions like isolated retrieval workstations are not really attractive or acceptable for end-users. Only if typical information science or documentation work (like retrieval) is an integrated part of other job-related information activities such as communication, calculation, simulation, word processing, or graphics, will it be accepted and used on a larger scale than is the case today.

Fig. 7 shows the curricular activities in the field of information retrieval which altogether reflect the tendency towards the integration of traditional information transfer (by means of information retrieval) into local processing, integrated business software, and intelligent, natural-language based and graphically supported information systems. Information scientists and information professionals can no longer restrict themselves to information (retrieval and data base) systems but must be aware that the advent of integrated and highly complex software packages such as LOTUS1.2.3, SYMPHONY, GEM, WINDOWS, KNOWLEDGEMAN, etc., is a new challenge for information workers. And the same is true for intelligent systems which in the form of expert systems will really change the world of information transfer and management.

5. KNOWLEDGE-BASED METHODS - CURRICULAR ASPECTS OF INTELLIGENT INFORMATION TRANSFER AND MANAGEMENT

The information science curriculum at the University of Constance has concentrated from the beginning on the linguistic aspects of information work. For this purpose we have chosen the concept of information linguistics[8]. We assume that the acceptance of information systems[9] and methods will highly depend on two factors:

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[8] cf. Kuhlen 1986; Hahn 1986

[9] By 'information systems' we would like to have understood all kinds of systems which consist of knowledge representation, storage, retrieval and processing components. Consequently we don't restrict information systems to the different types of reference/document or factual retrieval systems which are nowadays dominant on the information market, but, by all means, include all kinds of intelligent systems, such as question-answering/expert systems, translation systems, text condensation systems.

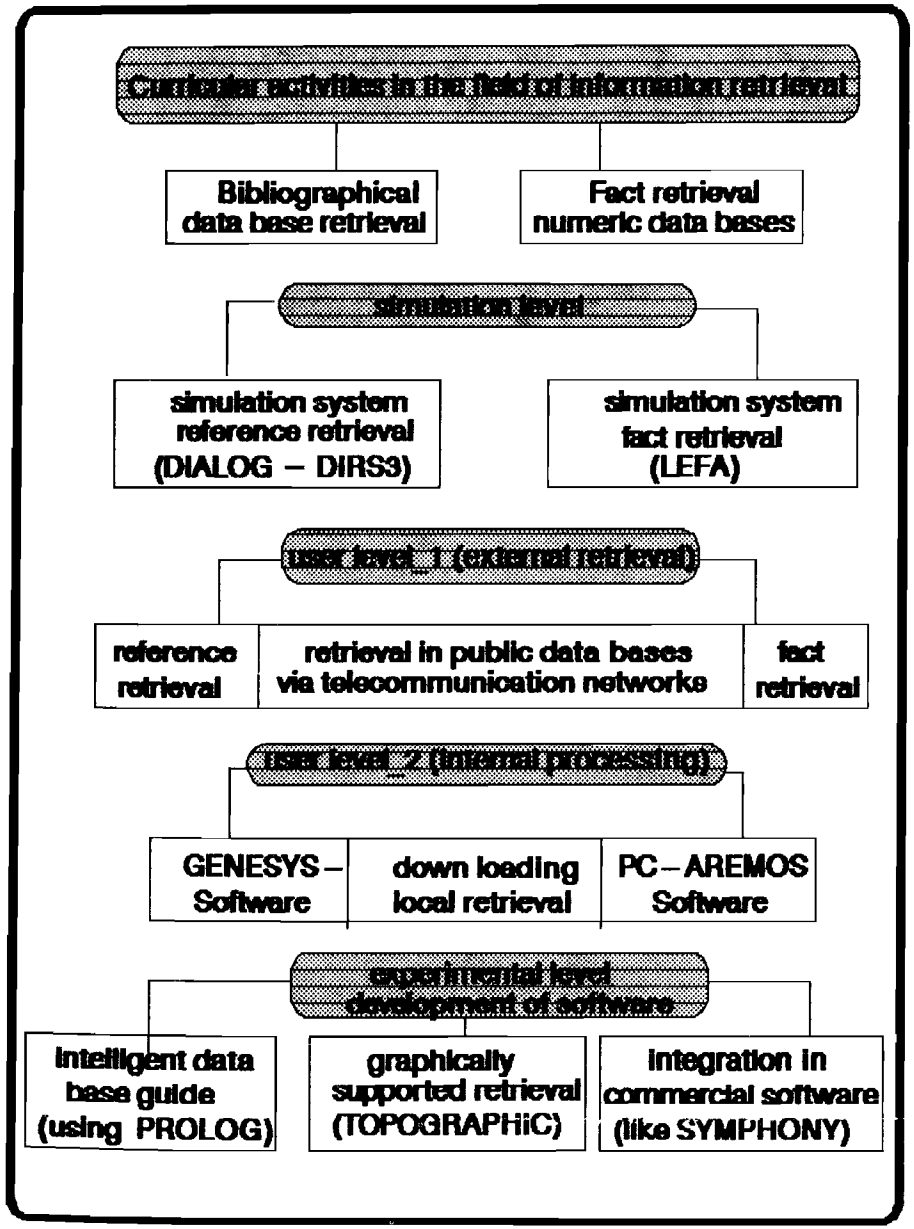

Figure 7. Aspects of Information Retrieval

a) The access to information systems should be possible in a way which is natural to human users; this requirement leads to the construction of natural-language based man-machine-communication systems (partly in competition with or in addition to other communication forms, like graphically supported interactions).

b) Information systems must have knowledge acquisition components, by which - with respect to language-based reference objects like textual documents - knowledge can be transformed into machine internal structures and can thus be processed according to predefined requirements of users, e.g. translation, question-answering, text condensation/abstracting.

In order to prepare our students with respect both to information transfer and information management, we offer the following courses:

a) Information linguistics I: Introduction into linguistic aspects of (current commercial) information retrieval

b) Information linguistics II: Linguistic and statistical methods of experimental information retrieval

c) Information linguistics III (Intelligent information systems): Procedures of artificial intelligence with respect to experimental information retrieval

d) Special courses for the application of information linguistic knowledge, covering topics such as automatic translation, indexing and retrieval, abstracting or question-answering.

These courses correspond to the following syllabi (with respect to information linguistics I-III):

a) Information linguistics I

- information and language
- domains and methods of information linguistics
- linguistic and statistical approaches to the graphematic analysis of spelling errors and spelling variations
- information processing on the word level: morphological reduction algorithms
- dictionary-dependent and -independent procedures for the determination of parts-of-speech
- partial parsing, recognition of nominal phrases
- introduction into the relational theory of semantics
- types of text, domain-specific languages
- information linguistic aspects of operating and experimental systems:
  - automatic indexing
  - automatic query support
  - automatic abstracting
  - automatic translation

b) Information linguistics II:

- methods of statistical information retrieval
  - vector- and non-vector-based similarities measures
  - statistical classification
- application of statistical information retrieval: SMART (Salton) as a prototype of experimental statistical information retrieval
- methods of linguistic information retrieval
  - phrase structure grammars/PSG parsers
  - encoding of semantic knowledge in machine dictionaries
- application of linguistic information retrieval: the LINGUISTIC STRING PROJECT as a prototype of linguistic information retrieval
- demonstration of selected German and international statistical and linguistic information retrieval systems

c) Information linguistics III:

- the concept of intelligent information systems
- methods of intelligent information systems
  - knowledge representation techniques
    - propositional and predicate logic
    - procedural representation forms
    - semantic networks
    - frames/scripts
    - semantic primitives/cases/roles
  - techniques for the transformation of knowledge
    - deduction/inferencing
    - rewriting rules
    - heuristics
    - fuzzy reasoning
- architecture of intelligent information systems
  - typology of intelligent information systems
    - language processing systems
    - question-answering-systems
    - text analysis systems
    - decision support systems
  - system components and their functions
    - world-independent knowledge bases
    - grammars, inferencing systems
    - world-dependent/domain-specific knowledge bases
    - strategic knowledge bases (meta knowledge)
- prototypes of intelligent information systems, mainly from the field of experts systems

d) Automatic translation as an example for a special application of information linguistics/knowledge-based methods
- introduction into the field of automatic translation historical development of automatic translation
- translation as a means of relevance decision
  - translation of titles, abstracts, multi-lingual access to data bases
- first generation systems: from Georgetown to SYSTRAN chances and limits of mainly word-oriented translation

- second generation (grammar-oriented) systems: TAUM-METEO concept of transfer, separation of algorithms and linguistic data
- third generation (knowledge-based) systems: basic concepts and experimental systems
- automatic and human translation
  - concept of translator's workstation
  - machine-aided translation
- terminology data banks (TEAM, EURODICAUTOM)
- the European translation system EUROTRA
- criteria for the evaluation of translation systems

Besides these courses, students have the possibility to deepen their knowledge by applying information linguistic and artificial intelligence methods in so called project courses. For reasons of prototyping we prefer PROLOG as a programming language. Advanced students, for the purpose of project or thesis work, thus write their own software programs using PROLOG, for example, for building up a small expert system, or defining a graphics based retrieval interface, or writing a routine for a text analysis parser.

Of course, not all of our students have the background, the skills, and the interest to do such work (especially the information management students who are more application-oriented, than programming- or system-development-oriented), but at least the emphasis on experimental work and system development is possible and, with respect to further work in our research projects, highly desirable. The direct contact to experimental and working intelligent systems is considered to be helpful for future work of information transfer specialists and information managers in an information environment which will be more and more influenced by knowledge-based (intelligent) techniques and systems.

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