FOURTH WORKSHOP ON RESEARCH DIRECTIONS FOR ARTIFICIAL INTELLIGENCE IN DESIGN

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THE FORMALIZATION PROCESS IN GLOBAL KNOWLEDGE HANDLING

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Abstract. The position paper discusses both long and short term issues in connection with artificial intelligence in design. A holistic view of the development is presented and future key research and problem areas pointed out. The main concepts discussed are the knowledge views—communication, representation and classification as well as methodological issues is presented. Projections into the near future what might be the research issues and implications of the current research are made as well as a framework for discussion of long term research issues. The paper states the importance of applying a connectionist view on building the future global Dynamic Knowledge Net establishing the networking of personal and computer stored knowledge.

1. Introduction

The position paper reflects my ideas on the long term development applied on more short term oriented activities. With short term I mean 10-20 years. A holistic view is taken to be able to grasp the essence of the ongoing paradigm shift.

"Big changes are taking place. We are in the beginning of a paradigm shift that probably is one of the greatest we have recorded. Figure 1 shows an unscientific interpretation and forecast on development of human wisdom (intellectual development) and material welfare (material development). The development is characterised by rather sudden shifts due to intellectual stepwise improvements (art of writing during Rome empire, art of printing, earth around the sun, and Newton's discoveries during the renaissance) and now the art of IT and digital information" (Christiansson, 1994; see also figure 1).

My interpretation of the development is that we oscillate up and down as we climb the abstraction ladder. We form concepts on higher levels and carry through the formalizing processes. This is coupled to making existing processes more effective. After a formalizing period we start to take in new ideas and analyze the situation more in detail. We enter a de-formalizing

period where we gain deeper understanding about the world. We are now in such a period, see also figure 4 in Christiansson (1994). A typical example is the emphasis on object oriented modelling starting around 1985 and now the emerging awareness of mixed and partly overlapping knowledge representations. The analysis period is going on with for example focus on work flow and document handling systems (see also figure 6).
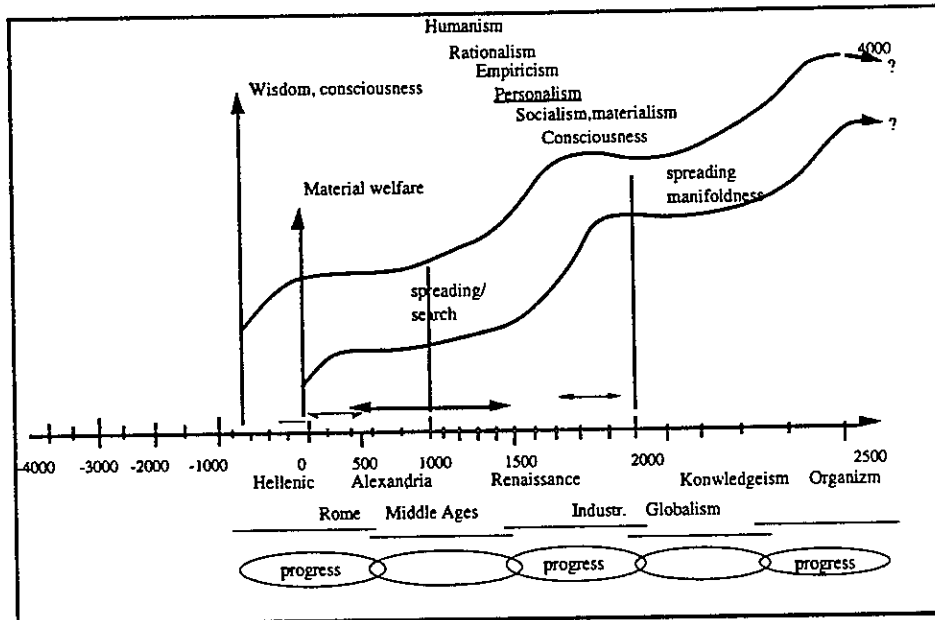

Figure 1. A unscientific view on development. What comes after the knowledge era?
(from Christiansson, 1994).

The formalization processes oscillations is constrained by the knowledge stored in peoples heads (it is hard to change already built up associations), organisational structures and stability of physical things and computer stored models of our reality.

2. The Paradigm Shift

How can we detect the ongoing paradigm shift?
— the world is shrinking down to a global village,
— all computer stored knowledge is available (the knowledge is there somewhere),
— general sense of increased knowledge level and thereby increased consciousness level and increased AWARENESS in different undertakings,

— reduced knowledge duplication production, by for example global conferences in the world wide web,

— increased travelling (more interesting people to meet in real reality)

— people defending positions. "Puzzles that resist solution are seen as anomalies rather than falsifications of a paradigm" (from 'Theories and Structures: 2. Kuhn's Paradigms' (Chalmers, 1978, p. 92)).

A lot of the ongoing research is explorative seeking deeper understanding and descriptions of phenomena, e.g. modelling of creative design (Gero and Maher, 1993) and connectionist representations (Ramsey, Stich and Rumelhart, 1991).

What can we expect will be the almost immediate visible results of the paradigm shift? One very important effect will be the reduction of existing constraints for knowledge handling and in a wider sense *knowledge communication.*

— The information *flow* will only partly be an actual flow of data bout more a dynamically changing *connection patterns* in the Dynamic Knowledge Net, *DKN* (see Christiansson, 1992). The Dynamic Knowledge Net, DKN, dynamically connect a mix of knowledge representations and people to make knowledge easily accessible and easy to augment.
Implications: Changed access patterns and 'container' descriptions,

— We will be able to *link* computerized knowledge and make it immediately accessible (compare with Ted Nelsons thoughts in the Xanadu project).
Implications: We need (changed) classification schemes (including libraries especially in their electronic form) and thereby implicitly described new computer stored models of our reality. The user of knowledge must have a deep understanding of what he or she is doing (certification problems). Knowledge will be easier to access and easier to misuse. Ethic considerations. Knowledge access rules. Agreements for referencing and linkage of knowledge .

— The knowledge linkage will be more *complete* than before (i.e. we will theoretically be able to get access to all knowledge on our portable computer or in the electronic meeting rooms).
Implications: Increased competence through specialists collaboration (holistic and detailed knowledge), focus on quality control, filtering mechanisms, information originality (who, when, change history),

— *Knowledge layering* and formalization issues,

— *Group behaviour* (negotiation, consensus, discussion, facts collection, etc.),

— Linkages to *historic* data (existing and old). Time marking and access possibilities.

The parallel development of *multimedia* interfaces to the computer stored models will greatly improve user control of and presence in the models.

— *Telepresens* with model overlay (remote presens, distant inspections, remote control, remote actions)
— *Virtual reality* with possibilities to experience the models in completely new and more effective ways (database visualizations, simulations, body and group control).
    Implications: Navigational metaphor development.
— *Electronic meeting rooms* with common access to knowledge and other electronic meeting rooms.
— A richer *multimedia* interface.
    Implications: will give raise to deeper experiences of the computer stored knowledge (rationale and *emotions*), richer *expressions in reasoning*, new *presentation* styles

3. Formalization

According to Webster (1993) we have the following definitions:

Formalize:	To give a certain or definite form to: to make formal.
Formal:	Belonging to or constituting the form or essence of a thing: relating to or involving the outward form, structure, relationships, or arrangements of elements rather than content.
Automation:	The technique of making an apparatus, a process, or a system operate automatically
Artificial Intelligence:	
	(1956) the capability of a machine to imitate intelligent human behaviour: a branch of computer science dealing with the simulation of intelligent behaviour in computers.
Intelligence:	The ability to learn or understand or to deal with new or trying situations: the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria (as tests).
Knowledge:	The fact or condition of knowing something with familiarity gained through experience or association: acquaintance with or understanding of science, art, or technique: the fact or condition of being aware of something.

"Knowledge has no specific definition. Depending on the philosophical school there are different views represented on the meaning of knowledge. According to traditional analyses a person knows that p if and only if (i) p is true, (ii) the person is convinced that p is true; (iii) the person has good, satisfactory or imperative reason to believe that p is true. That is a knowledge

(knowing) is identical to true, well-founded conviction" (Christiansson, 1994).

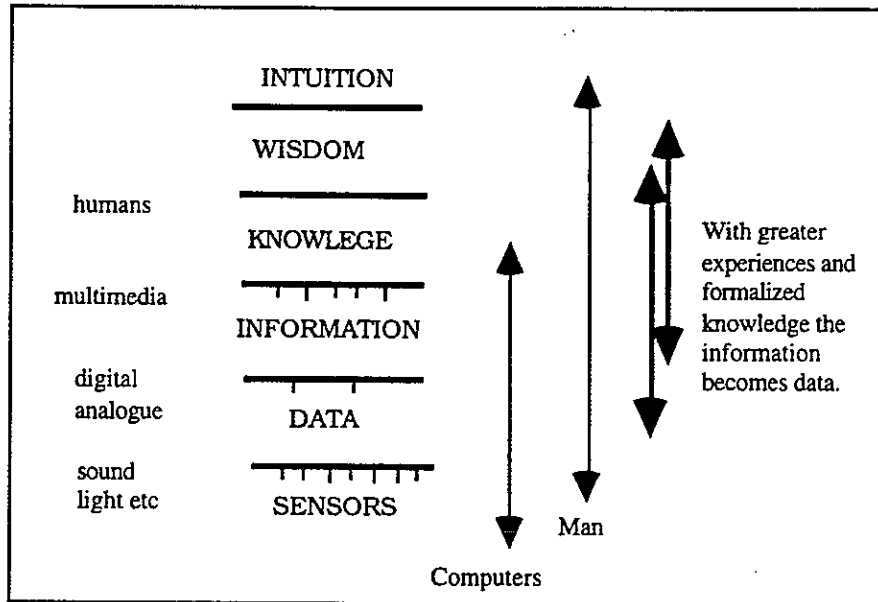In figure 2 a possible relation between data and knowledge is sketched.

Figure 2. The abstraction hierarchy of knowledge. Knowledge has a limited duration in time. (The world is not flat any longer).

4. Degrees of Freedom

We can end up with any systems to aid design. This I experienced in 1980 as I visited a capital in Europe where all new dwellings were produced more a less automatically. The architect would fill in forms according to figure 3. The input data was processed in a computer with 10 Mbytes of hard disc and the result delivered as manufacturing, transportation, and construction site schedules. This process was obviously highly formalized.

We may get more room for *exclusivity* as we can routinize some design activities. This should give room for more creative design. As we get more global impressions and influences the demand for better context descriptions increases

— descriptions of *culture* where the artefact/product will be used,
— descriptions of *working styles* for participating design environments,
— descriptions of *collaboration styles* for participating design environments,
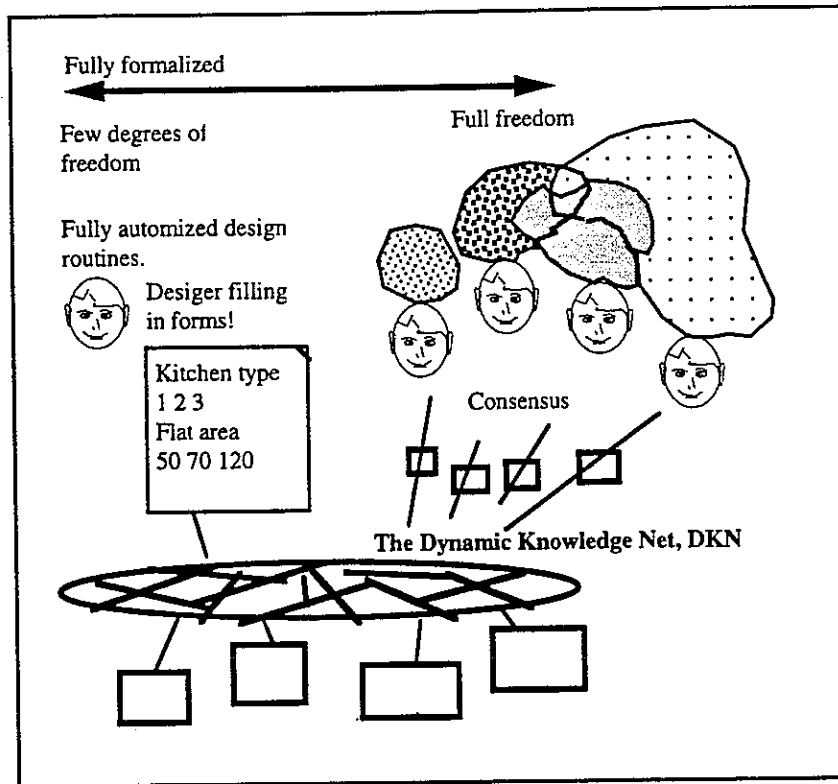— descriptions of *organizational* contexts.

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Figure 3. AI could lead to a more un-formalized design process with high quality results (client and user wishes fulfilled). The old building master's knowledge stored in one head must be shared among specialists (who possess deep and broad knowledge).

5. Driving Forces for Change

There may be different driving forces for change of things to the 'better'.
— A strive for achievement of the good life and respect for human dignity.
— A basic instinct to increased social consciousness and awareness through co-operating intellects.
— A desire to produce high quality and usable products.
— Curiosity.
— Increased power and control (which should automatically increase responsibilities). Knowledge→Decision→Responsibility→Power.
— Ability to sell unique/adapted packages of knowledge.
— Improved quality of the design environment and process.

6. Methodological Issues

How will the *quality* on supplied knowledge be secured in the emerging DKN? The researchers have responsibilities to create 'filters' with high level explanations to help users when navigating the DKN. New search mechanisms will develop and create a greater freedom in choosing search criteria.
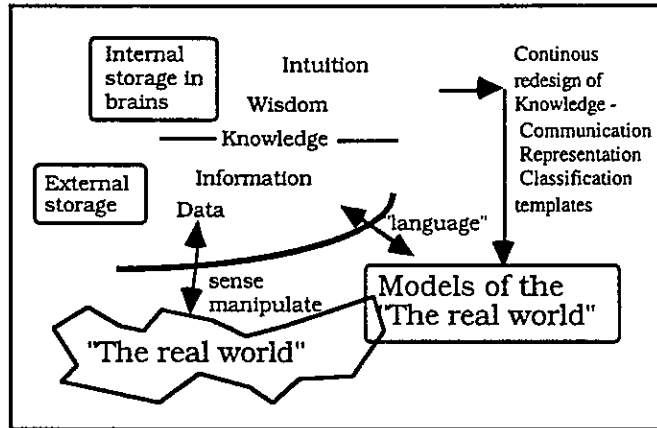

Figure 4. The knowledge carriers puts constraints on the change pace of the paradigm shift. The ultimate model of the world is the world itself including its inhabitants. A model represents a part of the world.
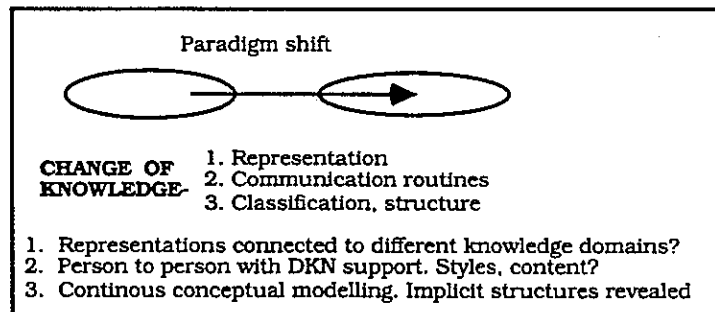

Figure 5. Three main views on knowledge during the paradigm shift.

Examples on the type of endeavours that can be undertaken:
— Test beds as "Worlds best practice under CIB W78.
— K3 Think Tank (Christiansson, 1994).
— Scenarios and visions creation with global feed back.
— Knowledge connections offerings in the world wide web, WWW.

Case-based reasoning (Kolodner, 1993) should be further developed to support daily access to knowledge and act as a driving force for investigating deep knowledge issues. (see also figure 6).

It is important to maintain bottom up - top down approaches in parallel (with both practical and theoretical undertakings)

7. Why Do We Formalize?

As we build up our collected knowledge we climb the abstraction ladder. We formalize and create meaningful concepts. We do this to get structure in our lives and to be able to meaningfully use knowledge.
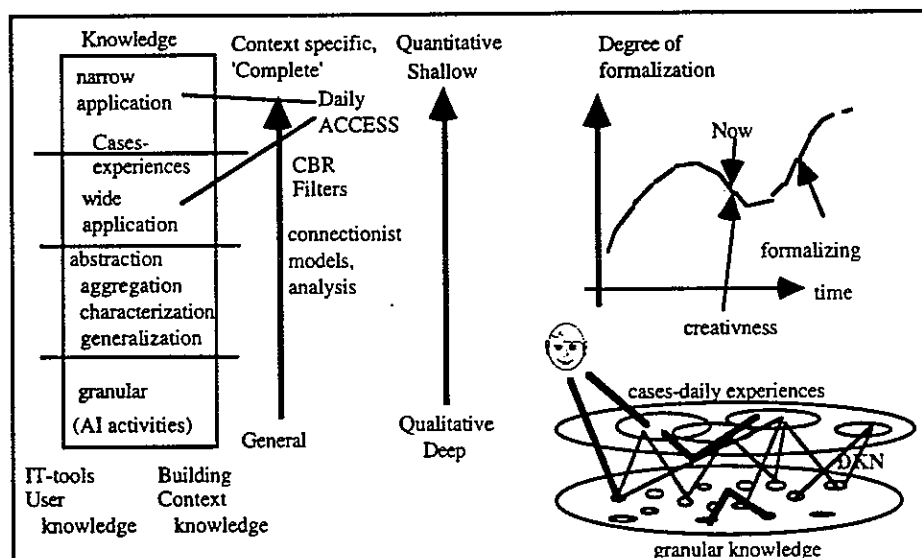
Figure 6. Knowledge described with regard to deepness, quality, and usabililty. It is also indicated that we are in a creative, de-formalizing phase of development contributing to the content of the deep knowledge containers. Formalization oscillations takes place on all knowledge abstraction levels with different frequencies.

How do we accumulate knowledge in our heads and in the computer systems? How do we un-learn computer systems? The questions are many and to a great extent unsolved when it comes to our personal knowledge handling. Though in case of computer stored knowledge we have obligations to be aware of what kind of babies/baby we are creating.

We will live in a turbulent era and will for a long time not have 'a general solution' to global computerized knowledge handling. In figure 6 I have sketched a possible interpretation of the situation. Important variables are:

— *time validity* for knowledge,

— *generality* and *applicability* of different knowledge,
— un-learn/de-formalize/forget *process* (is slow and sometimes impossible both in humans and computers),
— continuos evaluation of the *connection patterns* in the DKN (WWW, client-servers, distributed databases in a first phase),
— *quality assurance* on information and knowledge.

At the aggregation, abstraction level, deeper and more general (long time validity) knowledge is linked. This can be done explicitly using classical AI or implicitly by training connectionist models. In the latter case it is hard to de-compile the sub-symbolic clustering in a network.

Creative re-coupling could be done on the aggregation level which also can serve as transfer to other case-reasoning lines. This could be accomplished by
— moving a problem to a new context
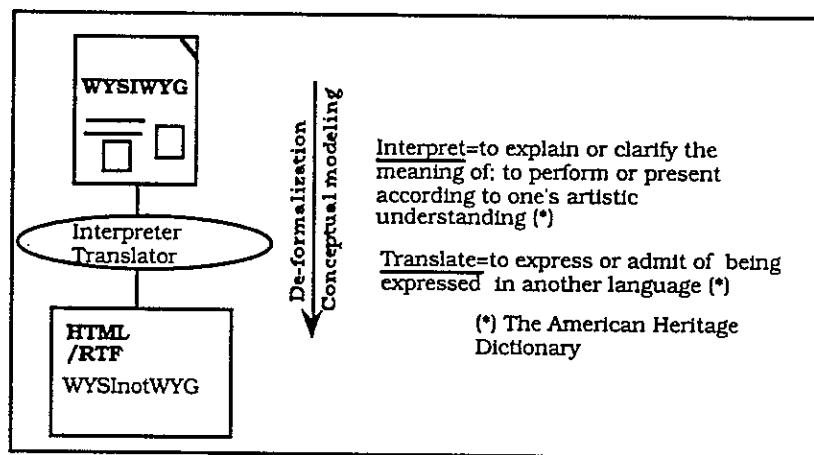— applying operators for establishing connections in new ways

Figure 7. Re-engineering of the WYSIWYG document to a hyper document in the world wide web, WWW.

Figure 7 shows an example on de-formalization. We are going back to the pre-WYSIWYG time to format documents so they will fit in their new hyper document form. We though still do not know the properties of a WWW-document but we express wishes and come up with new concepts.

8. Knowledge Communication and Representation

As knowledge will be ubiquitous - existing or being everywhere at the same time, (Webster, 1993), the main focus for the user during problem solving will be to

— be able *understand* the problem under consideration,
— to possess *required knowledge* for the problem solving,
— be prepared to actively *search* for knowledge.

Knowledge transfer is partly a pedagogical problem. The actual transfer process can be enhanced by IT tools by

— presenting good examples with explanations (cases),
— presenting causal explanations (why did we achieve this result?),
— telling stories (with story telling elements),
— giving access to question-answer pairs (with answers on three? levels; 1) one correct answer, 2) alternatives with explanations, 3) fundamental knowledge about the problem).

Different knowledge representations will be communicated optimally in different ways. We need to map the relations between applications, knowledge representations, and communication styles not forgetting

— the unlimited number of available connection patterns in the DKN,
— that the same knowledge may be stored in many ways and places (redundant)

We also need effective knowledge *search* methods (pattern search in DKN, content search as 'free text' search) and effective problem definition tools. Case-based reasoning could be one such tool (attacking ill-defined problems below heuristic level)

9. Knowledge Classification

Knowledge classification is tightly coupled to the way models are created in the DKN. The models can be more or less explicitly expressed. Models formalize (i) products (the fabricated artefact), (ii) processes (to get there and use it), (iii) users, and (iv) contexts (see figure 8).

A classification scheme contains, or should at least contain, a more or less explicit model of existing world view(s) and paradigms. It is important that we can use existing classifications in parallel to be able to get access to similar information from different electronic libraries.

A search should be possible over all resources with the same search method and search profile. We need global recommendations for mark-up of information connected in the DKN as well as secure methods for automatic classification and cross referencing between classification schemes

Old information marking must be maintained to reflect historic classifying schemes. As time goes by the definition of knowledge containers will change. May be we already can talk about 'virtual books' in the WWW.

Another central issue is how we can meaningfully store and transfer personal experiences for future use before the owner is dead? See also figure

3, which implicate personal knowledge to be less tacit because reasoning occurs between many persons in a complex design situation.
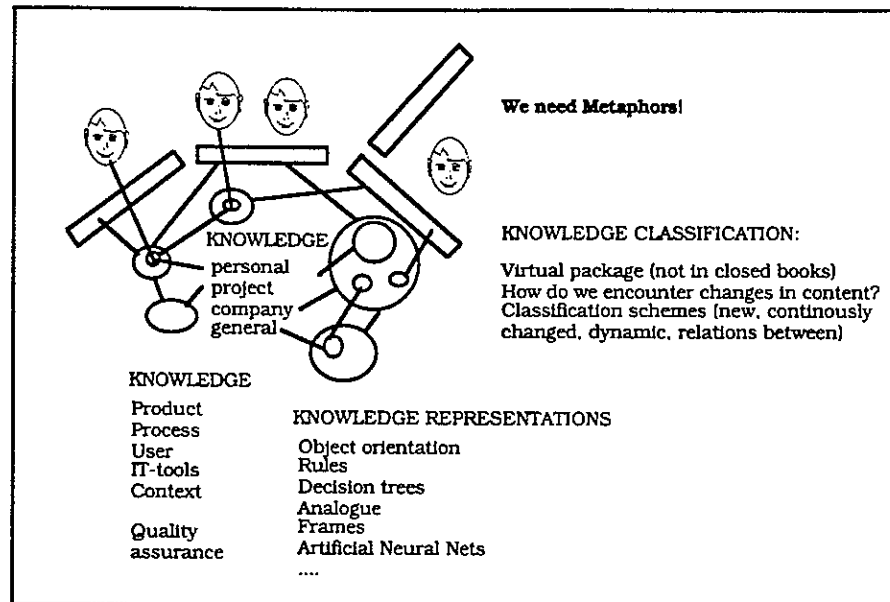

Figure 8. Knowledge is classified according to content and usage.

10. Future Directions and Implications

The main message of this paper is that the world shrinks, that we must take a global perspective when taking out directions for the future, and that a view on knowledge at a higher consciousness level (reducing access constraints influences) slowly emerges through a global Dynamic Knowledge Net, DKN.

The short term implications for research are (use global scale)

— *New concepts* formulations on knowledge—communication, representation and classification and tryout of the ideas on real situations.

— *Implementation* and *demonstration* as joint activities between research and industry. (Also globally).

— Support for a *attitude change* and de-formalization (forgetting), situation analyses and favouring of creative thinking.

— Creation of *scenarios* (trends clarifications) and *visions*.

— *Knowledge transfer* activities to industry. Intensified education at universities.

- World wide *think tank activities* as the proposed K3 program on Knowledge—Communication, Representation and Classification (Christiansson, 1994)
- Agreements on *IT-tools 'standards'* and protocols (component documents, agent properties and communication protocols etc.).
- Models for *collaboration activities* supported by the DKN (negotiation, facts collection, discussions, agreement documentations, etc.)
- General *IT-tools descriptions* and wishes.
- *Context descriptions* (cultural differences, working styles, etc.).
- Knowledge *announcements* procedures in the DKN.

Long term implications for research issues and directions

- *Pattern* talk in the Dynamic Knowledge Net.
- *De-formalization* processes in DKN.
- Knowledge *representations* in the DKN and their descriptions.
- Advanced model control through *multimedia* interfaces.
- Advanced *classification* schemes.

PostScript

Use the village metaphor on the global community exchanging individuals with individuals and groups of persons, visualize a global rule maintainer mechanism (the village chief) and DKN democracy procedures. Regard the DKN as the first generation global neural network.

References

Chalmers A. F.: 1982/1978, *What is This Thing Called Science?* (2nd edn), Open University Press, 178 pp.

Christiansson, P.: 1992, Dynamic knowledge nets in a changing building process, *Automation in Construction* 1 (1993), Elsevier, pp. 307-322.

Christiansson, P.: 1994, The K3 Program, 1994, *Proceedings International Workshop on the Future Directions of Computer-Aided Engineering*, Carnegie Mellon University, Pittsburgh, pp. 189-194.

Gero, G. and Maher, M. (eds): 1990, *Modeling Creativity and Knowledge-Based Creative Design*,. Lawrence Erlbaum, 351pp.

Kolodner, J.: 1993, *Cased-Based Reasoning*, Morgan Kaufmann, 668pp.

Ramsey, W., Stich, S. P. and Rumelhart, D. E. (eds): 1991, *Philosophy and Connectionist Theory*, Lawrence Erlbaum, 320pp.

Merriam Webster's Collegiate Dictionary. 1993, (10th edn). Merriam-Webster, Inc., Springfield, Massachusetts, 1559pp.