Analysis in analysis

Matti Pettersson
University of Tampere
Department of Computer Science
P.O.Box 607
FIN-33101 Tampere
Finland
mpe@cs.uta.fi

ABSTRACT

Research in cognitive psychology suggest that the concepts human beings use vary across individuals, time and contexts. In this paper we study implications of these findings for system analysis methodologies. These methodologies seem to assume stability and generalizability of mental entities and thus the interrelations of concepts, operations and technology are poorly understood. Based on studies in cognitive psychology, two conclusions are made: First, a theory view of system development is proposed. Second, to ensure development of both the concepts and the technology, system development should be understood as a creative learning process.

1 Introduction

Research in human–computer interaction (HCI) is dominated by a cognitivist model, which casts humans as information processors (Wallace and Anderson, 1993). Wallace and Anderson show, that many HCI methods depend on basic assumptions of the cognitivist model. These assumptions include conceptual models, similarity between human cognition and artificial information processing systems and the generalizability of mental mechanisms from one individual to another. In this paper we show that, what is true for HCI methods in particular is true for methods in other areas of system development as well.

Wallace and Anderson (1993) suggest substituting cognitive science by a more context centred approach to HCI, like that based on ecological approach. Our position is, that a sound theory should include both: ecology and the results of cognitive studies. But during the decade, which human as an information processor view has been dominating the field of HCI, cognitive psychology has gone through profound changes. The basic assumptions concerning conceptual structures—their formalizability and generalizability across individuals, time and contexts—have been questioned and new, more context sensitive theories have been suggested within cognitive psychology itself. In this paper, we study, how those changes affect HCI methods and more generally, methods of analysis. We start by a short review of two important studies in cognitive psychology. The first one studies definitions of concepts and the second one instability of concepts.

In the second part of the paper we analyse two common methods for analysis: information modeling and task analysis. We show that the methods poorly understand the interrelation of concepts and operations. Finally we discuss some consequences of the study.

2 Studies of concepts

2.1 Theory view of concepts

A common assumption is that meaning of data or knowledge of an individual can be predefined and represented in a formal way. This assumption is analogical to the classical view of categorization, which suggests that categories are defined by singly necessary and jointly sufficient features of objects. This sounds intuitive, but many categories may not conform to this view and on the other hand, even if we had a set of defining features it does not guarantee the sensibility of the category (Murphy and Medin, 1985). As an example consider a category consisting of striped things that have more than one leg and that weight between 11 and 240kg.

Beside the classical view there are also other established views of categorization: the probabilistic view and the exemplar view (Murphy and Medin, 1985). The probabilistic view is a looser formulation of the classical view. It denies that there is a common core of criterial properties and argues that concepts may be presented in terms of features that are typical or characteristic, rather than defining. The probability that an object belongs to a certain category increases while its typicality (in terms of the set of features given) increases. But basically, the criticism against the classical view applies against the probabilistic view as well. The exemplar view claims that categories may be represented by their individual exemplars rather than by some unitary description. Beside exemplar selection, the problem with this view is that it relies on the concept of similarity (as do the two other views as well in one form or other). Similarity itself is a fuzzy concept: one may ask what does it mean that two objects are similar (if they are not exact copies)?

Murphy and Medin (1985) conclude, that all these views are insufficient. They see three major problems in the exclusive focus on similarity and the associated practice of breaking the concepts into constituent attributes or components: First, it leads naturally to the assumption that categorization is based solely on attribute matching; second, it ignores the problem of how one decides what is to count as an attribute; and third, it engenders a tendency to view concepts (i.e. mental representations of categories) as being little more than the sum of their constituent components. Human interests, needs, goals and theories are ignored.

Murphy and Medin (1985) suggest a theory view of categorization. Their starting point is the observation that categorization may be based on an inference process. For example, jumping in a swimming pool with one's clothes on is not, in all probability, a feature associated with the concept *intoxicated*, and still in some cases, from the context of jumping we may be able to infer that the person is drunk (and thus intoxicated). And in a different context the behaviour described may imply heroism (e.g., jumping into the pool to save someone from drowning).

In the example inference is based on a ‘theory’ of how some events are causally related. This is one instance of theory in the sense the term is used by Murphy and Medin (1985). They use ‘theory’ to mean any of a host of mental explanations, rather than a complete organized scientific account. The theories people use may often not reach the rigour and consistency expected from a scientific theory. Examples of a theory include: causal knowledge, scripts (entailment relations), knowledge of rules, scientific knowledge. Theories don't need to be explicit either; people use some kind of theoretical knowledge implicitly. Theory has actually two roles: inside concepts and between concepts. Inside a concept, theory is the glue that holds the concept together. Between concepts, theory determines what concepts we actually have. Note, however, that explaining categorization by theories does not bring categorization to a firmed basis as theories and their application are based on—similarity. In the example above the interference might go as follows: 'That person sat quite long in the bar. Now he is swimming in the pool. Sitting in the bar and consuming to much alcohol may entail behaviour like that (i.e. similar behaviour).' What we get by including theories is a richer structure.

2.2 Instability of concepts

An implicit assumption underlying many studies related to cognitive science is that knowledge structures are stable. This assumption seems reasonable. If you know something, this knowing is relatively permanent, at least if that knowledge is actively used. Moreover, communication seems to require stability. Taken two persons with unstable knowledge structures, how can they ever understand each other? Literature does not unanimously support the stability assumption. First of all, it is known that the cues most effective in accessing a memory trace at retrieval are those most similar to its encoding context. This suggest that the representation of a phenomenon depends on the context of encoding. Second, subsequent experience may continually change previously acquired information.

Barsalou (1989) conducted a series of studies to find out whether different individuals represent a given category in the same way and whether a given individual represents a category in the same way across contexts. Methods used were grading and property generating. In grading, subjects were asked to order a list of exemplars of a category based on their typicality. In property generating, subjects listed properties shared by members of a category. The evidence against the stability assumption seems convincing. To assess agreement *within subjects* the overlap between a subject's protocol for a category on one day and his or her protocol in the same context a few weeks later was computed. The average overlap found was around .55, indicating that only a little more than half a subject's protocol for a category in one session overlapped with his or her protocol in the other.

Moreover, Barsalou's studies challenge the common assumption that concepts appear similar from an individual to another. To assess agreement of a given category *between subjects* the average overlap in properties was computed. Across experiments the overlap was around .32, indicating that only about one-third of a subject's description overlapped with another subject's description for the same category. Property generation also seems to vary with context. The average overlap between all possible pairs of subjects *across* contexts was computed and compared these values to the average overlap *within* contexts. Subjects taking different points of view agreed less (.16) than subjects taking the same point of view (.2).

Taken together

> these findings illustrate substantial instability in category representations. Different people do not use the same representation for a particular category, and a given person does not represent a category the same way across contexts. Instead the representation of a given category varies substantially between and within individuals (Barsalou, 1989).

Barsalou (1989) explains these results by basic retrieval mechanisms: accessibility and contextual cuing. From his point of view accessibility provides a central source of instability particularly across individuals. Even though most people in a population may have the same basic knowledge for a category, the accessibility of this information may vary between individuals. Because the highly accessible information for a category varies from individual to individual, different individuals retrieve different information when initially accessing it. Within individuals, everyday experience may constantly change the accessibility of category information and thereby produce instability. Contextual cuing makes category representations still more dynamic. Even though most people may have the same basic knowledge for a category, the contexts that different people experience have the potential to cue different information and thereby cause between–subject instability. Within an individual, experiencing a category in different contexts would similarly cue different information and thereby cause within–subject instability.

To give a more specific explanation for the instability of representations, Barsalou (1989) describes information represented by a concept in terms of three types: context–independent information (CI) and two types of context–dependent information (CD). Barsalou uses the term concept to refer only to temporarily constructed representations. A concept is thus a particular individual's conception of a category on a particular occasion. And rather than being definitional concepts simply provide an individual with useful expectations about a category.

Context–independent information constitutes conceptual cores. It is the information that is activated every time a concept is constructed for a category. For example, *unpleasant smell* is activated as a part of every conception of a skunk, independent of context. Information becomes CI after it has been incorporated into a concept on numerous occasions. Context–independent information for a particular individual depends thus on his or her experience and can change over time. Assumptions about what CI contains seem to vary along the lines of general categorization theories described above. In general it is inferred that information that becomes CI must be such that it is often used. Two types of properties are likely to be activated: properties that have high diagnosticity and properties relevant to how people typically interact with instances of a concept (Murphy and Medin, 1985). This actually binds the concepts and operations together. If an object is often operated in a certain way, the properties relevant to those operations are likely to become CI of the corresponding concept.

3 Analysing analysis

The studies reviewed above are related to the problem of interrelations of concepts, human beings and objects of the real world. A classic way to describe these interrelations graphically is in a form of a triangle as in Figure 1. The corners of the triangle correspond to concept[1] , human being and objects of the real world and the sides of the triangle to the relations (or actually interaction) between these entities. Engeström (1987) suggests that none of these relations is direct. There is no direct connection between concepts and reality, human beings and concepts or human beings and reality. All these relations are mediated: The relation between concepts and reality is mediated by a human being, the relation between a human being and reality is mediated by concepts and the relation between concepts and a human being is mediated by reality.

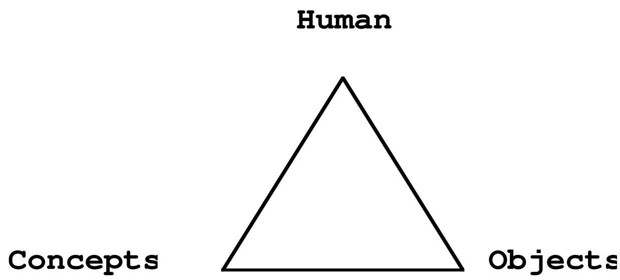

Figure 1. A graphical representation of the interrelations of concepts, human being and objects of the real world.

The studies by Murphy and Medin (1985) and Barsalou (1989) seem to confirm the active role of humans in the conceptualization of the real world and its dependence on the overall context. Murphy and Medin show that features of objects that are important from the point of view of conceptualization do not have any specific role within the objects themselves. Their only significance is their particular role for the human being. Barsalou's studies give support to the hypothesis that the reality and concepts are not directly related. If reality mapped directly to our minds, concepts would appear invariable across individuals.

This simple framework can be used in a study of system development and methods of analysis in particular. Traditionally, systems development proceeds in three phases: analysis, design and implementation. The straightforward placement of the phases one after another is often challenged, but it is still often seen useful to classify activities during development along these lines. This separation of concerns is in one form or another replicated in several approaches to system development. From the existing physical system, the technologically independent logic or essence (McMenamin and Palmer, 1984) is extracted as a starting point for the design of the new system. Only features extracted may vary: In SA (DeMarco, 1979), the features are data and activities, in information modeling they are data or concepts users have, in task analysis they are user's tasks.

The triad of concepts, human being and reality gives us a possibility to analyse differing approaches to analysis as many of them refer to cognitive psychology more or less directly. For example, cognitive psychology is one of the most dominating theories un-

[1] We use the term ‘concept’ in the triangle instead of more classic terms ‘sign’ or ‘symbol’.

derlying research in human–computer interaction. Beside, cognitive psychology has relevance in the study of analysis in general, as analysis itself is mental activity. The mental character of analysis shows up, if one asks why some features of objects are selected to the models resulting from analysis whereas other features remain untouched. In analysis textbooks this is usually 'explained' by referring to the relevance or essential nature of the features captured, which do not—as discussed above—have any particular role within the reality itself, but depend on the subject conducting the analysis and his interests and purposes. In the following sections we study two common traditions to analysis, information modeling and task analysis in the framework described above.

Note, however, that our framework is too simple to serve as a theory of analysis in general as understanding the dynamics of conceptualization in full requires a social aspect (Engeström, 1987) neglected in this paper. But as such the framework gives a critical point of view to analysis.

3.1 Information modeling

We use the term information modeling to denote various approaches to analysis common to which is that data is seen central to an information system. The approaches include data modeling, information modeling and conceptual modeling. We do not give a detailed survey of each of these, but rather support our study by some examples from the literature.

Data modeling, evolved during the 70', does not pose the question of the origin of the design. Models describe the data structures for access and storage of data (Lyytinen, 1987). It is up to the talent of the designer to find the most suitable design. This approach has some continuity in information systems methodologies. For example, in the comparative review edited by Olle, Sol and Verrijn-Stuart (1982), Aschim and Mostue (1982) describe their methodology as consisting of several definition tasks without any consideration of the possible origins of the definitions. In a similar fashion Gustafsson, Karlsson and Bubenko (1982) explain that 'the unifying and fundamental task during the early, problem and application analysis stages is to create and specify a theory.'

This can be illustrated in terms of the triangle from Fig.1, by leaving the reality corner out (see Figure 2). The arrow leading from human (designer) to concepts (design) indicates that the design is produced by the designer in a straightforward way. Even the subject is often omitted and authors describe their methodology solely in the passive voice (see e.g. Rzevski, Trafford and Wells, 1982).

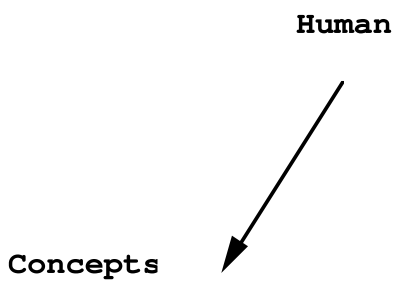

Figure 2. Data modeling in the framework from Fig. 1. It is up to the talent of the designer (human) to produce the most suitable design (concepts).

A more advanced, but analogical is the linguistic approach described by Sølvberg (1982). He sees as one of the major activities in development to develop a common terminology, which covers the most important concepts in the system and its environment. The linguistic approach is more advanced in the sense that it sees the social nature of the terminology, but as all is tied to the linguistic level only, the relation of the concepts and the reality remains unexplored. As a result it is, for example, impossible to tell what criteria to use to select important concepts among less important and whether there are any constraints for the development of the terminology.

Some authors within the tradition note that the origin of the design is the existing reality. It is no wonder that a strong position in this direction is taken within standardisations efforts. ANSI/SPARC report (1975) states that an information system mirrors the deterministic behaviour of the Universe of Discourse thus supposing a direct relation of mental entities to the reality. At the first glance this seems to offer a firm and objective basis for analysis and design, but against the background of this paper this is less obvious. What features are selected from the reality still depend on the subject doing the analysis and his interests.

Some authors understand that reality does not automatically transfer to models, but modeling is done by a human being. For example, Rolland and Richard (1982, 370-71) recognize a subject, object and means to do the analysis: "The designer perceives and analyses the Universe of Discourse to achieve a complete, consistent, not redundant and economical representation." However, it is usually supposed that the model is an objective model of the reality (Lyytinen, 1987) and thus the name reality modeling. The role of the subject is passive or mechanistic. This type of thinking is illustrated in Figure 3. The figure is a triangle i.e. all the corners, human, concepts and reality, are included. The arrows from the object to human being and from human being to concepts are dotted to indicate their secondary role in comparison to primary, straight relation from reality to concepts.

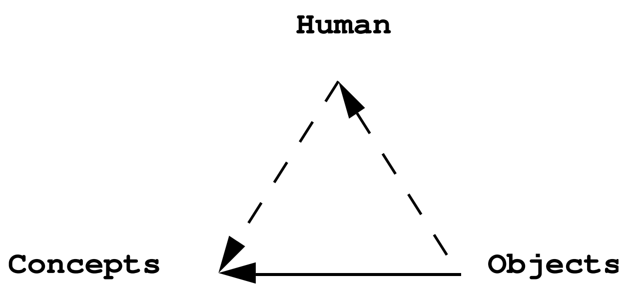

Figure 3. In reality modeling it is supposed that the impact of the human being can be eliminated.

When compared to reality, models are much poorer in content. This is reflected by some authors suggesting that there is a some kind of abstraction process, from reality to models. For example, Verheijen and van Bekkum (1982) use the term 'abstraction system' to denote a mental model of the object system, which is further defined as a part of the reality (see also the discussion in Lindgreen, 1992). As the aim of the abstraction is to find a technology independent, i.e. conceptual, model of the data, this type of approach is often referred as conceptual modeling.

The authors suppose some kind of selection process, but they seem not to be able to explain the process in more detail. Kangassalo (1993) takes a step further by accepting concepts in human mind as the object of the analysis. In his COMIC methodology it is suggested that the designer elicits knowledge about the UoD from the users and describes it as a concept structure. So there are actually two mappings, first from the reality to users' minds and second from users' minds to the concept structure. This is a real step forward, from somewhat mystical transition of features from reality to models. Analysis is explicitly bound to real subjects and it is recognised that the object of study in analysis is primarily, not the reality itself, but the conceptualizations people have of the reality. A similar suggestion is actually made by Chen in his seminal paper on ER –modeling (1976).

There are two ways to handle the problem of variability of concepts in COMIC. First, the instability within an individual is taken into the account by checking concept definitions in another session. Second, in schema integration each individual's schema is included without any changes as long as the result is internally consistent. In cases of conflict, a relative weight is given to each individual schema and conflict are solved in favour of the most important schema. The question of assigning the weights is not addressed.

But what still remains open is a deeper understanding of the relation of concepts and reality. Kangassalo supposes that concepts form an adequate and subject independent model of the reality, which should be shared by all members of the organization. Figure 4. describes Kangassalo's approach. Human being still has a passive role in perceiving the reality. The relation of human and concepts has no direction to indicate the fact that in modeling, concepts are further reflected by a human being.

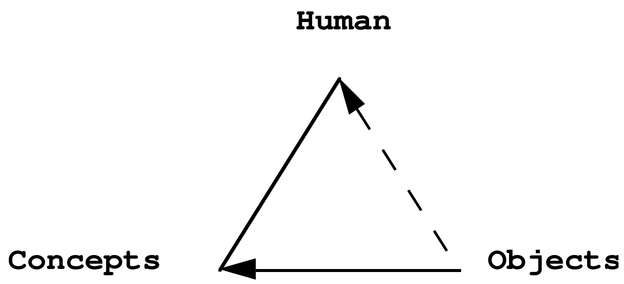

Figure 4. COMIC methodology (Kangassalo, 1993) builds a model of the reality by modeling users' concepts.

Unfortunately one more problem emerges as concepts are described as concept structures. Concept structures are supposed to correspond to definitions of concepts. The basic assumption behind COMIC methodology is that concepts can be formally defined via their components. The discussion in the first part of this paper suggests that there are concepts that are not easily described formally. The concept of concept is such. Flensburg (1986) gives a nice example of the difficulty of defining such a simple and common object like a table in an acceptable way.

Common to the approaches to analysis referred to above is the aim to model the data around which the information system can be build. They share the view that data is more stable than and independent of the operations manipulating the data. Unfortunately this assumption prevents the authors of these approaches from explaining in detail, why some features of the reality are more relevant than the others. The discussion in the first part of this paper suggests that the relevance depends on the operations humans execute in relation to those objects (c.f. Murphy and Medin, 1985). The tradition taking human operations as a starting point for analysis is task analysis. In the next section we study the basic assumptions underlying various approaches to task analysis.

3.2 Task analysis

The basic assumption behind the use of task analysis in system development is that human operations towards achieving a goal are —at some level of abstraction— stable and independent of technology to the extent that they can be used as a basis out of which the computer based system can be derived. Task analysis in general appears in several forms and there is actually no consensus among practitioners, what TA is. Some people feel that task analysis is about eliciting the actual behaviour of those people known to competent at the task. Others are more concerned with focusing on what could, in principle be achieved by human being. Other approaches focus upon the goals that need to be achieved to meet system requirements, and then explore the ways in which the human operator may be limited in achieving these goals or the means by which they may be achieved (Shepherd, 1989).

Classic form of task analysis is a hierarchical description of tasks, HTA (hierarchic task analysis). We follow the description given by Shepherd (1989). In HTA the description starts from goals. Goals are related to attaining desired states of systems under control or supervision. Usually a goal may be attained in a number of ways. A goal which has to be attained by a person has an associated task, which is a means of attaining the goal. From this point of view task is a system's concept. What people actually do are operations. Task analysis examines what people need to do to attain the goals. Goals can be described at various levels of detail, and in terms of sets of subgoals, which is the basic idea in HTA and task analysis in general. Goals are also organized in the form of plans. Plans specify, how suboperations are organized to achieve an overall goal, when each subgoal should be carried out. Again, plan is a systems rather than behavioural concept. It states the conditions under which each of the constituent subgoals needs to be carried out in order that the overall goal is attained successfully.

Figure 5. shows the basic assumptions of HTA as described by Shepherd (1989). There are only two corners corresponding to human being and objects. Both ends of the arrow are dotted to indicate that from the point of view of HTA they are actually irrelevant. HTA is not interested in who is executing a task or what objects are affected. The direction of the arrow from subject to object shows the direction of impact: the subject manipulates the object, but the object has no effect upon the subject.

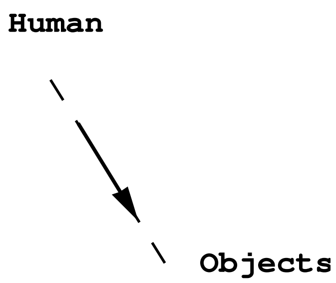

Figure 5. HTA is interested how task can be accomplished. The subject and the objects are not of importance.

Interpreted as above, task analysis avoids discussion about the interrelations of concepts and reality. By binding all basic concepts to the successful attainment of a goal they turn out to be properties of the system. However, this is quite problematic. As an example consider microwave cooker. Certainly there is a certain sequence of operations i.e. a plan that should be followed to get a meal cooked. This plan probably corresponds to the way in which the designer of the oven thought it to be used. But in that sense plan is not a useful concept while designing artefacts unless we assume that there is one (or a few) explicitly stated, optimal strategy to attain the goal, which should be followed by everyone. This may work in simple cases.

In complex cases the use of a plan in design is based on the supposition that the plan is already known to the user or it can be easily learned. In both cases it is assumed that plan has a behavioural dimension too. In complex cases, it is a risk from the point of view of usability of the system, if the designer believes that he has found a plan and incorporates it as a part of the system. It may lead to a situation, where other, perhaps more natural ways of using the system may turn out to be impossible. For example, some CASE tools force the analysis to proceed in a strict top–down manner (Vessey, Jarvenpaa and Tractinsky, 1992), whereas experienced professionals seem to apply both strategies —top–down and bottom–up— interleaved (Curtis, 1990; see also the discussion in Orlikowski, 1991). Moreover, there are some cases where there is no plan in this sense. Shepherd (1989) himself gives some examples, where HTA is not applicable: HTA itself, decision making and 'changing gear' in a car. For example changing gear requires manipulating the accelerator pedal and the clutch, but the coordination of these two actions is subtle. Also for unforeseen circumstances we cannot be explicit about what the operator should do.

Some authors add the cognitive dimension to TA by analysing tasks to find the knowledge needed to execute tasks. These approaches are based on the fact that concepts and conceptualizations play an important role in human behaviour. For example, Johnson's (1989) methodology is based on an extension of the GOMS model (Card, Moran and Newell, 1983) called TKS (Task Knowledge Structure). Johnson assumes that people have knowledge associated with tasks. What is the exact form of this knowledge is left open, but he argues that TKSs are functionally equivalent to the knowledge structures that people do posses and use when performing a task. The method for identifying the knowledge for a TKS, Knowledge Analysis of Tasks (KAT) includes finding out various components of a task including roles, goals, subgoals, subtasks, plans, procedures, strategies, actions and objects. There are several possible methods to identify these components ranging from observation to interviews and from existing documentation to the analyst herself performing the task. Lot of attention is paid to ensure the representativeness of the results.

Johnson (1989) notes that there is no criteria for relevance beside intuition. However, when compared to information modelling task analysis considers both the operations and objects, thus making a cross checking possible. One weakness in this approach is the overestimation of cognition. Once the operations, the objects and the knowledge are identified, the reality and the context of the operations can be forgotten. At the same time the operator can be forgotten as there is no need for an interpretation from the events in the context to the operations of the system. Presented in a pointed way, it is supposed that the knowledge (concepts) alone controls the objects. In Figure 6, this is described as an arrow from concepts to objects.

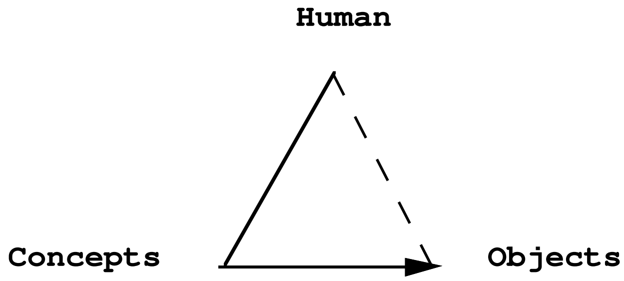

Figure 6. The basic assumptions behind TKS (Johnson, 1989): the knowledge directly controls the objects.

4 Conclusions

4.1 Theory view of system analysis

Analysis plays a central role while building the designer's model of the system. Most of the methods cited above take the analysis of the application domain as a starting point for development. We assume that this is a necessary step towards human problem–domain communication as sug-gested by Fisher (1991). Moreover, we associate the human problem–domain communication to the distinction between to types of knowledge: 'how it works' vs. 'how to work it' (Halasz and Moran, 1983). Authors usually discuss these two types of knowledge in relation to a device, which leads to a question of the level of detail: If the device is a computer, should the operator know how a computer works (c.f. Fisher, 1991). Knowledge of how the objects of the application domain behave, is higher level knowledge of the type 'how it works'.

Some of the methods cited above seem to suppose building a subject independent model of the domain, whereas some methods try to model user's conception of the domain thus helping the user to model the system or matching the system to user's expectations. The theory view of Murphy and Medin (1985) suggest that we should analyse the operations users execute towards the objects of the domain and the theories they have. Naur (1985) suggests that a programmer builds a theory of the program and of how it relates to the affairs of the world. Even if Naur does not make it explicit his view seems to imply a theory of the domain too. Ryle's (1963) notion of theory used by Naur has similar features as that of Murphy and Medin (1985). Gustafsson, Karlsson and

Bubenko (1982) relate their methodology to a theory. They model the domain in terms of entities and events. Their target is an objective model of the domain and their notion of theory is formal, including facts, axioms and theorems. Quite similar is the approach suggested by Kangassalo (1990, 1993). He equals modeling with finding good concepts for a factual theory.

This seems to make visible the problem of the relation of formal and informal. A computer based system is —by definition— formal. On the other hand, if we build systems to match the conceptualizations and theories users have and the context of use, we have to predefine and formalize something that seems to be impossible to predefine and formalize: the concepts and the context. Our suggestion is that we should avoid far reaching formalizations in the form of a formal specification or the program code. Moreover we should explore implementation strategies that allow an easy modification of the boundary of formal and informal. (As examples of such systems see Trevor, Rodden and Blair, 1993, Riekert, 1991 and Taivalsaari, 1994).

4.2 Development as creative learning

Our analysis shows that relation of operations and concepts and their dependence on the context of use are poorly understood in methods. This shows up clearly in the discussion of technology (in)dependence. This seems to bother the proponents of the task analysis too. For example, Diaper (Diaper and Addison, 1992) claims that TA is technology independent, but elsewhere he takes the opposite position:

> Current practice in a task is frequently tied to the existing technology employed in the task and it is therefore difficult to produce a creative, novel solution to the system design based on such methods (cit. from Carey, Stammers and Astley, 1989).

In the first part of this paper we concluded that operations and concepts are two sides of the same coin: concepts guide operations towards objects and operations determine how we conceptualize the objects. This means that there is even a deeper connection between the current practice and the existing technology than what can be seen at the surface. The concepts a human being has are, at least partially, determined by the technology he uses. For example, an image was not a relevant feature of an object for a user of an information system some years ago. Only technological advancement made both images and operations manipulating them possible. No analysis of existing reality or existing conceptualizations of the reality would have given a specification of a system that incorporates images into an information system.

This is related to the deeper problem how we view information technology. Is it only a means to streamline the existing flow of activities: to combine and eliminate actions and shorten the durations of certain activities (Ang, 1993)? Or is it a means to facilitate a qualitatively better practice? If we accept the latter view, then we must admit that traditional methods of analysis are insufficient. They do not result to a specification of the new system. Changing both practice and concepts presupposes learning.

The view of system development as a learning process is not new. Higgins and Safayeni (1984) consider, whether it is easier for the technology expert to learn to know the application domain or for the domain expert to learn technologies. But if we are looking for creative, novel solutions, then a mechanistic concatenation of the two types of knowledge is not enough. Lanzara (1983) considers design as a creative inquiry. He criticises the analytic view of design process for seeing the problem as an external entity that is to be processed by applying standard rules and procedures to transform it into a solution. He notes that in real–life situations the designer experiences the problem as a unique situation, characterized by uncertainty and ambiguity. What is needed is a creative learning process (see Engeström, 1987),What is needed is a creative learning process, where the participants learn something that is not yet there, find new conceptualizations of the application domain. Analysis plays a role in that learning. But methods of analysis should show how concepts and operations related to the current practice depend on technology thus supporting the qualitative change with the aid of the technology.

References:

Ang J.S.K. (1993), Performance criteria of a sound office analysis methodology, in *International Journal of Information Management, Vol 13, (51-67).*

ANSI/X3/SPARC (1975), Study Group on data base management systems, Interim Report, *FDT-Bulletin, Vol 7, No 2*.

Aschim F. and Mostue B.M. (1982), IFIP WG 8.1 case solved using sysdoc and systemator, in *Olle, Sol and Verrijn-Stuart (Eds) (1982).*

Barsalou L. (1989), Intraconcept similarity and its implications for interconcept similarity, in *Vosniadou S. and Ortony A.(eds), Similarity and analogical reasoning,* Cambridge University Press.

Card S.K., Moran T.P. and Newell A. (1983), The psychology of human computer interaction, Lawrence Erlbaum.

Carey M.S., Stammers R.B. and Astley J.A. (1989), Human–computer interaction design: the potential and pitfalls of Hierarchical Task Analysis, in *Diaper (1989).*

Chen P. (1976), The Entity-Relationship model—toward a unified view of data, in *ACM Transactions on Database Systems, Vol 1, No 1, (9-36).*

Curtis B. (1990), Empirical studies of the software design process, in *Diaper et al. (Eds), Human–Computer Interaction—INTERACT'90 Conference Proceedings*, North Holland.

DeMarco T. (1979), Structured Analysis and System Specification, Yourdon Press.

Diaper D. (ed.) (1989), Task Analysis For Human–Computer Interaction, Ellis Horwood.

Diaper D. and Addison M. (1992), Task analysis and system analysis for software development, in *Interacting with Computers, Vol.4, No.1*.

Engeström Y. (1987), Learning by Expanding, Orienta-Konsultit.

Fisher G. (1991), The importance of models in making complex systems comprehensible, in *Tauber and Ackerman (1991).*

Flensburg P. (1986), Personlig databehandling: introduktion, konsekvenser, möjligheter, Studentlitteratur.

Gustafsson M.R., Karlsson T. and Bubenko J. (1982), A declarative approach to conceptual information modeling, in *Olle, Sol and Verrijn–Stuart, (1982).*

Halasz F. and Moran T.P. (1983), Mental models and problem solving using a calculator, in *Proceedings of the CHI'83 Conference.*

Higgins C.A. and Safayeni F.R. (1984) A critical appraisal of task taxonomies as a tool for studying office activities, in *ACM Transactions in Office Information Systems, Vol.2, No.4, (331-339).*

Johnson P. (1989), Supporting system design by analyzing current task knowledge, in *Diaper (1989).*

Kangassalo H. (1990), Foundations of conceptual modelling: a theory construction view, in *Kangassalo H., Ohsuga S.and Jaakkola H. (eds.), Information modelling and knowledge bases, IOS Press.*

Kangassalo H. (1993), COMIC: A system and methodology for conceptual modelling and information construction, *Data & Knowledge Engineering 9, 287-319.*

Lindgreen P. (1992), A general framework for understanding semantic structures, in *Falkenberg E.D., Rolland C., El-Sayed E.N. (Eds), Information system concepts: improving the understanding*, North-Holland.

Lyytinen K. (1987), Two views of information modeling, *Information and Management 12, 9-19.*

McMenamin S. and Palmer J. (1984), Essential Systems Analysis, Yourdon Press.

Murphy G.L. and Medin D.L.(1985), The Role of Theories in Conceptual Coherence, in *Psychological Review, vol 92, No 3.*

Naur P. (1985), Programming as theory building, Microprocessing and Microprogramming, vol.15, 253-261.

Olle T.W., Sol H.G. and Verrijn-Stuart A.A. (Eds) (1982), Information systems design methodologies: A comparative review, North-Holland.

Orlikowski W. (1991), Integrated information environment or matrix of control? The contradictory implications of information technology, in *Accting., Mgmt.& Info. Tech., Vol.1, No.1, pp 9-42.*

Riekert W.-F. (1991), Knowledge acquisition as an object–oriented modelling process, in *Tauber and Ackerman (1991).*

Rolland C. and Richard C. (1982), The Remore methodology for information systems design and management, in *Olle, Sol and Verrijn–Stuart, (1982).*

Rzevski G., Trafford D.B. and Wells M. (1982), The evolutionary design methodology applied to information systems, in *Olle, Sol and Verrijn–Stuart, (1982).*

Shepherd A. (1989), Analysis and training in information technology tasks, in *Diaper (1989).*

Sølvberg A. (1982), A draft proposal for integrating system specification models, in *Olle, Sol and Verrijn–Stuart, (1982).*

Taivalsaari A. (1994), A critical view of inheritance and reusability in object–oriented programming, Jyväskylä studies in computer science, economics and statistics, 23, University of Jyväskylä.

Tauber M.J. and Ackerman D. (1991), Mental Models and Human–Computer Interaction 2, Elsevier.

Trevor J., Rodden T. and Blair G. (1993), COLA: A lightweight platform for CSCW, in *De Michelis G., Simone C. and Schmidt K. (Eds), Proceedings of the Third European Conference on Computer–Supported Cooperative Work.*

Verheijen G.M.A. and van Bekkum J. (1982), NIAM: an information analysis method, in *Olle, Sol and Verrijn–Stuart, (1982).*

Vessey I., Jarvenpaa S. and Tractinsky N. (1992), Evaluation of vendor products: CASE tools as methodology companions, in *Communications of the ACM, Vol.35, No.4.*

Wallace M.D. and Anderson T.J. (1993), The stagnation of theory in HCI, paper presented at HCI'93 Conference.