

# Drawing on Practices for Modeling Socio-Technical Systems

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**Abstract:** The formal description of pedagogical scenarios and learning processes has attracted a lot of attention among researchers and developers in recent years. Nevertheless current modeling approaches resemble the notion of workflows and hence fall short in describing the situated and socially mediated nature of practice. Against this background the paper describes an alternative modeling approach as well as its theoretical foundation and practical implications.

## Introduction

The formal description of pedagogical scenarios and learning processes has resulted in a couple of specifications focusing on individual as well as collaborative activities. The explicit and formal representation of educational processes is relevant for quite diverse reasons. Besides their technical and economic relevance they also provide a tool of communication as they allow to share experiences and to coordinate activities among those involved in the design and development process. Furthermore they are of interest for learning scientists as they provide a frame of reference for the analysis and comparison of different scenarios. While current educational modeling languages such as IMS Learning Design (IMS, 2003) overcome the problem of de-contextualized learning objects by describing the use of these objects within a unit of study, they resemble traditional workflow models and hence reproduce the problem on a higher level. Even though these approaches acknowledge the complex nature of learning processes they are reductive (the educational process equals the sum of the learning activities entailed). Thereby the situated and socially mediated character of human action is neglected. Against this background this paper outlines an alternative modeling approach which draws on activity theoretical as well as systemic theories to depict practices. The paper is structured as follows: Key assumptions of the cultural-historical activity theory (Leontjew, 1978) as well as the Theory of Social Systems (Luhman, 1995) are introduced to outline the underlying rationale of the modeling approach. Referring to the theoretical foundations the modeling approach is presented. In a further work the modeling approach is presented in details and the practical implications are discussed.

## The Concept of Practice

The concept of practice can be defined as “the ways of doing work, grounded in tradition and shared by a group of workers” (Bødker, 1991). While the concept of practice can basically be defined as a customary way of doing things, it seems worthwhile to have a closer look at this concept from a theoretical point of view. The following is a list of key-assumption on human-activity and social systems. Here we state, that the concept of activity systems and social systems hold common assumptions.

Key assumptions of activity theory (AT): AT is a philosophical framework and descriptive tool focusing on understanding human activity and work practices. It is based upon the psychological theory of A. N. Leontjew (1978) and L. S. Vygotsky (1978). (1) Human activity is object-oriented, i.e. it is directed towards a physical or conceptual object that is transformed by the activity. It is the *object of an activity* and not the goal that allows distinguishing different activities from one another. Artifacts are not objects by themselves, but can become an object of activity when they are targeted and transformed in the course of an activity. The difference between an artifact in the sense of a real entity and the object of an activity is crucial as one and the same artifact can be used for a multitude of different purposes in different activities, while the object of activity is unique for every activity. (2) Activities are always mediated by tools and signs, which are constitutive elements of the activity system. Tools and signs are mediators which range from physical to conceptual artefacts (e.g. knives, plans, spreadsheets, scientific theories, and languages). Tools capture and preserve the socially shared knowledge developed in a given community and mediate the subjects' relation with the object of the activity as well as with other human beings (cp. Leontjew, 1978; Stahl, 2003). (3) Human activity whether carried out individually or collectively cannot be detached from its social context as its meaning is bound to its interpretation within a collective. (4) Activities are shaped by contextual conditions and circumstances. Human activity has to continuously adapt its actions and operations to external events

and circumstances. As a consequence human activity is guided but not predefined and determined by plans (Bardram, 1997). (5) The relationship between subjects, objects, and tools is reciprocal. The elements within an activity system are mutually interdependent, which means that a change in one of them will inevitably alter the other ones. In this sense the constituents of an activity form a system where each component is defined in relation to the other components. (6) According to Leontjew (1978) three levels of activity can be distinguished, namely collective *activities* which are carried out on a communal level often involving multiple actors, *actions* that are performed by a single subject to achieve a certain goal relevant to the collective activity, and *operations* in the form of fine grained automated routines. But even though activities are structured hierarchically Leontjew notes that the relation between operations and actions as well as actions and activities is not an additive one. Therefore it is not possible to simply decompose an activity into a set of actions. The difference between a set of actions and an activity is not a quantitative but a qualitative one. (7) Practices are never static but evolve when contradictions or tensions emerge between the elements in an activity system. Due to the systemic nature of practices changes in one element or the relation between elements usually affect the entire system. Due to their dynamic nature practices are historical entities in the sense that they change and develop in time.

Key assumptions of the Theory of Social Systems (TSS): TSS (Luhmann, 1995) is a descriptive framework presenting a system-centered view and a non-deterministic and non-prescriptive meta-theory. It is a variant of the General System Theory (e.g. Parsons, 1951). Parsons (1951) argues that societies as well as biological organisms aim at homeostasis (maintaining a stable state), and that their parts can be understood only in terms of the whole. (1) The difference system/environment is the central paradigm. The TSS describes the world in terms of systems, drawing a difference between a system and its environment. Whereas e.g. in object-oriented modeling objects and categories are defined, the TSS states that the difference system/environment is constructed. “The central paradigm of recent system theory is ‘system and environment’. The concepts of function and functional analysis no longer refer to ‘the system’ (...) but to the relationship between system and environment.” (Luhmann, 1995). The difference system/environment is not ontological but an epistemological. “This leads to a radical de-ontologizing of objects as such (...). This interpretation contains no unambiguous localization of any sort of ‘items’ within the world, nor any unambiguous classifying relation between them.” (Luhmann, 1995). (2) Personal systems as well as social systems are meaning processing systems as they are processing information by constructing meaning. A social system is not the group of people it contains. The social system is of different quality as there are different levels of emergence. Meaning is processed according to the actual state and current structure of the system and is defined by the system itself. (3) Persons (personal systems) do not belong to a social system but to its environment (Luhmann, 1995). This means, a person (and any other entity/type) does not belong to a system for all intents and purposes but in some respect, filling a specific role. Thus, a system can not determine another. (4) Elements within a system generate each other, e.g. in listening, the audience creates the speaker and vice versa. (5) Systems organize their inner complexity and reduce contextual (environmental) complexity. Systems are closed and self-regulated. Processes are inherently in-determined from an observer’s point of view.

## Modeling (Knowledge) Practices as Coherent Social Systems

This section outlines a modeling approach for modeling socio-technical systems. As this paper rethinks the epistemological foundation of modeling socio-technical systems, the approach goes beyond specifying specific concepts and relations and addresses the meta-level of modeling. The approach is based on three major inputs. (1) Distinguishing the meta-level categories *natural type* from *role type* to distinguish between an object and its role within a specific context/system (Guarino et al., 1994; Steimann, 2000), (2) introducing a system-centered perspective to reduce complexity and to model elements which generate each other within a system (*n-ary relations*), and (3) integrating basic assumptions of AT in order to overcome shortcomings of workflow models which work as means-end-models (different levels of emergence). Guarino et al. (1994) provide an ontological distinction, separating the meta-level categories *role types* from *natural types*. This distinction is based on the meta-properties identity and rigidity. Natural types (types) are semantically rigid (an instance of a class once and forever belongs to that class; it cannot change it without losing its identity) and not founded. Role types (roles) are not semantically rigid (instances of types can fill, adopt and leave a role without losing their identity) but founded (defined by context and relation). In figure 1 a rectangle indicates a type, a circle indicates a role, e.g. an instance of the type *artifact* fills the role *tool* within a specific context/system. Guarino et al. (1994) and Steimann (2000) define the meta-level category *role type* (role) as a binary relation. A role is defined by its relation to another role. We state, that roles within a system are reciprocal and mutually interdependent as elements within a system generate each other. Thus, this work models *action* and *activity* as *n-ary relation*. Furthermore, action and activity are

modeled on different levels of emergence. The modeling approach takes into account several key assumptions of AT and the TSS and has practical implications: (1) Activities (such as learning) are contextualized (distinguishing between role- and type-based attributes of the entities involved). (2) Activities can not be de-composed and reduced to a chain of actions without a loss of information (the relation operations/actions as well as actions/activity is not an additive one). Current modeling languages treat activities as self-contained entities related to other activities via respective pre- and post-conditions (organized hierarchically, sequentially or in parallel). (3) The elements of a system generate each other reciprocally. It is important to note that the model described so far is a meta-model providing the semantics but not the syntax of a respective modeling language. Accordingly the aim is not to demonstrate the practical utility of a particular modeling language but the general implications of the meta-model proposed. Further work is to be done in specifying a modeling language (based on the meta-model presented in this paper) to describe practices and socio technical systems in the field of CSCL and CSCW.

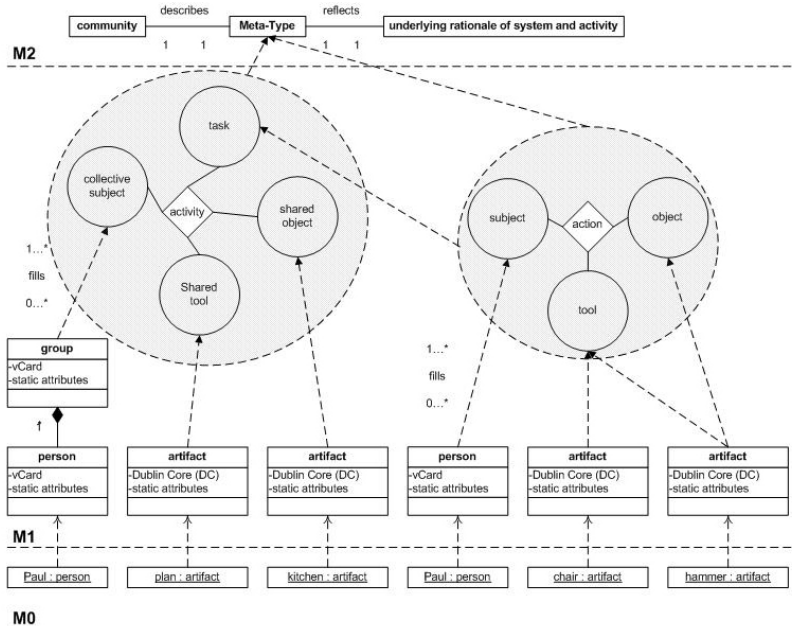


Figure 1: The meta-model of a system-centered role-based modeling approach, in UML.

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