Support for Object-Oriented Model Construction

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ABSTRACT

We discuss a design solution for a learning environment for students of object-oriented modeling. An overall goal in this work has been to ensure a design that is well grounded both theoretically and empirically. The design of the tools relate to central issues in cognitive apprenticeship and situated learning. Theoretical and practical design considerations are presented for each of the learning environment and results from empirical studies are discussed.

THEORY GROUNDED DESIGN

Theories of learning are important for the design of computer based learning environments but these cannot simply be applied and used in the process of design. (Jonassen & Land, 2000). We describe our design approach for incorporating cognitive apprenticeship and situated action in the design of a learning environment for computer science students of object oriented (OO) modeling. The purpose of object-oriented modeling is to create models of an enterprise that can be used for the subsequent design and construction of supporting communication and information systems. The learning environment consists of three tools aiming to support cognitive apprenticeship style learning for object oriented modeling (Collins, Brown, & Newman, 1989). Two of the tools (what we call expert problem solving tracks, and a library of modeling patterns) support aspects of authentic activity, i.e., an activity that help "students to foresee their participation in activities that matter beyond school" (Greeno, 1997, p.11). The third tool (a pedagogical assistant) support reflection and meta-cognition.

Theories that emphasize the situated properties of human action and learning (Lave & Wenger, 1991); (Collins et al., 1989) are very influential on current understandings of these phenomena and have been extensively used in analyses of learning (Jordan & Henderson, 1995). In our work we explore this new focus and the conditions it provides for designers of learning environments. An overall goal work has been to ensure a design that is well grounded both theoretically and empirically (Land & Hanaffin, 2000). This has led to two important design activities. The first was to explicitly state what aspects of the theoretical framework that we wanted to support in our design. The second activity came as a consequence of our theoretical framework which emphasizes learning in so-called authentic activities. This was to conduct studies on experienced conceptual modelers in order to get an understanding of how they acted when solving problems. The results of these studies were used to design particular aspects of the learning environment and in the evaluations of how learners interacted with the learning environment (Tholander, 2001).

Collins, Brown, & Newman provide a framework (cognitive apprenticeship) that designers of learning environments should consider (Collins et al., 1989). In our design we have identified the following aspects to be particularly important to consider in order to promote students to get engaged in the cognitive practices of conceptual modeling. First, learners should engage in *authentic problem solving* to develop skills that help them put knowledge into use. Knowledge of concepts and methods must not be learnt as abstract notions, but in a context where the practice of their use is uncovered. Second, *observation* of experienced practitioners' problem solving help student to develop their own problem solving strategies. Third, learners should practice to use experienced modelers' *language, concepts, and tools* in order to see the role of these concepts in practice. Fourth, learners should *reflect* on their own problem solving, and on their use of tools and concepts in relation to how experienced practitioners use these.

Learning and Doing Object Oriented Modeling

The first three aspects of our design focus above (authentic problem-solving, observing experienced practitioners, tool and language use) all include aspects of how experienced modelers go about in their problem solving. To be able to design tools for learners that support these aspects it is essential to ground the design in an understanding of how experienced modelers reason and carry out tasks. Therefore a think-aloud study with experienced modelers was conducted. The goal of the study was to find out characteristics about the different ways modelers solve problems in order to understand important elements of the cognitive practice they work in. The most important findings of the study were (see also (Karlgren, Tholander, Dahlqvist, & Ramberg, 1998)): First, in the problems experienced modelers face, they tend to identify familiarities with other problems which they have experienced and use these to solve the current problem, i.e,. they engage *in case based reasoning*. Second, they often go back and reflect on the overall nature and goal of the task, i.e., they show a high degree of *meta-cognitive thinking*. Third, they discuss with stakeholders how important concepts in the problem domain should be understood. They do not presuppose certain interpretations of the concepts based on their own ideas. Fourth, they refer to general problems and solutions that they often face in their everyday practice, i.e. they use *analysis patterns* (Fowler, 1997). Fifth, they proceed iteratively by solving sub-problems that they move back and forth between because they know that concepts are very dependent upon each other.

We have designed three tools to support students of object oriented modeling practice. *First*, expert problem solving tracks designed to support *authentic problem solving* (the first learning focus), *observation* (the second learning focus), and use of experienced practitioners *language, concepts, and tools* (the third learning focus*)*. The purpose of this tool is to present modeling tasks that provide the same *kind of* problems and complexity which conceptual modelers face in the 'real world'. Through this tool we want the students to get exposed to scenarios that resemble authentic environments including how experienced modelers go about to solve complex problems and how they talk about them. Emphasis is on the authentic practices of experienced modelers and on the language they use.

Second, library of modeling patterns designed to *support authentic problem solving* and also use of experienced practitioners *language, concepts, and tools*. One of the goals of the project was that students should learn to create models at a level of abstraction that makes them reusable in future situations. Our way of supporting learners in this is through analysis patterns, which are abstractions of common knowledge in object oriented modeling. Our study on experienced modelers showed that these aspects are often referred to through analysis patterns. We view analysis patterns as representations of the *language, concepts and tools*, which the students should practice to use, not as special constructs that they should memorize.

Third, the pedagogical assistant provides comments with the purpose to encourage the students to reflect and think critically (the fourth learning focus). Students should not take their preconceptions about their solutions, their knowledge, and the problem domain they are modeling for granted. As the students construct their models, the assistant asks questions and gives critical remarks about why the students have created some particular objects or relations, comments about the way the student approaches the problem, or gives advice about good ways of approaching such a problem. We have created three types of comments, first, comments about some particular objects and relations in the model being constructed, second, about important issues in the enterprise that must be represented in the model, and third, about some general problematic modeling issues in the solution.

Two studies of students using the learning environment have been conducted. In the studies, students solved modeling problems with the learning environment for 60 minutes. An important finding was the collaboration that students engaged in. The tools became mediating artifacts between the students and something to use as support for discussion and to come up with new solutions from. The learning environment expanded the conceptual apparatus that the students could use to reason with and helped them to see their solutions from new perspectives.

Summary

In this work we have taken a well-defined theoretical position based on cognitive apprenticeship and situated learning. The point of this work has been to explicitly design solutions based on these models of learning in order to investigate how such models can and must be adapted to particular circumstances. The purpose has been to discuss how theoretical and practical issues have been taken under consideration in our design.

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