# Matching Model Representations to Task Demands

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**Abstract:** In CSCL environments model representations can stimulate learners to explicate their reasoning and elicit and support knowledge construction. But literature on their effectiveness is not clear with data indicating that representations not adapted to task demands have counterproductive effects. By matching the representational guidance of a model representation to the demands of the task, learners can be supported during their collaborative inquiry process because they receive the information they need when they need it.

Generally speaking, the goal of collaborative inquiry learning is to have learners create a well developed conceptual understanding of a subject such that they are able to solve problems concerning that subject (Jonassen, 2003). This conceptual understanding is considered to be well developed when it has achieved an integration of both qualitative and quantitative knowledge representations of the subject matter (White, & Frederiksen, 1990). Such an understanding enables learners: to understand the core concepts and principles of the subject matter and the interrelationships between them *(qualitative problem representation)*, to make calculations according to these principles and to understand the outcome of these calculations *(quantitative problem representation)*. However, research shows that learners encounter at least two difficulties when working with multiple representations, namely, (1) problems translating from and coordinating between different kinds of representations (Ainsworth, 1999), and (2) incongruence between a representation and the task demands of a specific inquiry phase (Van Bruggen, Boshuizen, & Kirschner, 2003). In the *orientation phase* of problem solution, the learning task is less structured and aimed at constructing a global problem representation. In order to find a proper overview of the problem, qualitative knowledge is more appropriate for constructing a cognitive bridge between the learners' initial mental model and the mental model that has to be created (Jackson, Stratford, Krajcik, & Soloway, 1996). In the *solution phase*, the task is more structured in the sense that learners must produce concrete solutions by making the relationship between the problem and the proposed solutions explicit by identifying causal relations. The knowledge remains qualitative, but it contains - along with the central concepts of the problem - causal information that supports learners in finding multiple solutions to the problem. During the *evaluation phase*, learners are occupied with simulating their proposed solutions and gaining insight into their effects. Learners must compare their proposed solutions with each other, "forcing" them to look at alternative possibilities. This task has a quantitative character and can only be understood if the learners have a well developed qualitative conceptual understanding of the subject matter.

A *mismatch* between representation and task demands is detrimental for learning and must be avoided. Therefore it is important to determine what model representation is congruent with the task demand of a specific inquiry phase. This can be achieved by determining the *representational guidance* that a model has (Suthers, 1998).

## Representational Guidance of Model Representations

The representational guidance of a model is determined by its constraints and its salience (see Table 1). *Constraints* refers to what is expressed in the model: the concepts and their interrelationships (i.e., specificity), and how accurate they are represented (i.e., precision). *Salience* refers to the differences in expressiveness, caused by the different constraints, and which leads to the determination of the number and types of inferences that can be made. Less specific and less precise models have the advantage of having a high processability (Larkin, & Simon, 1987); it is rather easy to make many inferences from such models (i.e., elaboration). Those models guide learners in elaborating about the concepts of the subject matter and in relating them to the problem (Jonassen, 2003). However, such simple models do not have much expressive power (Cox, 1999); the inferences cannot be very detailed. The order of a model determines in what way learners can reason about the subject matter (White, & Frederiksen, 1990), determining the quality of the inferences. A zero order model supports reasoning about the concepts and in relating them to the problem in qualitative way. A first order model is more expressive and supports reasoning about causal relationships and guides discussion of possible solutions. A second order model is the most expressive and guides learners in making quantitative inferences which should enable them to come to a final solution.

Each inquiry phase matches a specific model because the representational guidance of the model is congruent with the task demands of that phase. A mismatch means that the model is incongruent with the task demands. Reasons for this could be that the model is too simplistic because it contains no relevant information, or it is too complex because learners do not have enough prior knowledge of the subject matter to grasp the complexity of the model.

Table 1: Specification of the model representations

| Inquiry Phase | Model representation | Representational guidance | | | |
|---|---|---|---|---|---|
| | | Constraints | | Salience | |
| | | | | | |
| Orientation | Conceptual model | Low | Undirected relations | Zero | Unstructured |
| Solution | Prediction model | Middle | Causal directed relations | First | Quasi-structured |
| Evaluation | Simulation model | High | Model directed relations | Second | Structured |

### Research Goal

The focus of the study is on determining whether a model representation is suited for coping with the task demands of a specific inquiry phase. If learners receive the information they need when they need it, their inquiry process will lead to a better developed conceptual understanding, making it easier to solve current and future problems concerning the subject matter.

### Design and Expectations

Learning triads have to solve a business economics problem in a computer supported collaborative inquiry-based learning environment. We have chosen for collaborative learning because learner discussion provides insight into the inquiry process itself and the conceptual understanding of the subject matter. All experimental groups must solve the problem by working collaboratively through three different inquiry phases with different task demands. In the three mismatch conditions, the groups receive a different model representation (i.e., conceptual-, prediction- or simulation model) which matches only with the task demands of one of the three inquiry phases (i.e., orientation-, solution- or evaluation phase). In the fourth condition, the groups receive all three models in a phased order. That is: they receive the most suited model for each inquiry phase (i.e., there is a match between task demands and models for all inquiry phases).

By analyzing the dialogue protocols and the quality of the answers of each inquiry phase, the effects and congruence expectations of the different model representations will be determined. We expect that congruent models lead to better task performance for a specific inquiry phase than incongruent models. Furthermore, we expect that the groups from the complete match condition will arrive at a better solution to the problem and create a better developed conceptual understanding because their knowledge has evolved in a more progressive way.

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