Ontology Development at the Conceptual Level for Theory-Aware ITS Authoring Systems

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Abstract. This paper presents ontology engineering at the conceptual level, based on case analysis where an author (a human or software agent), assisted by an ITS authoring system, needs to select an instructional strategy (method) in order to develop a learning scenario or environment. A detailed description of the development process at the conceptual level is provided, followed by the presentation of its results. Outstanding issues raised therein will be shared for further reflection.

Keywords: Ontology, Ontological Engineering, Intelligent Tutoring Systems, Authoring Environments, Instructional Science, Learning Scenario.

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Introduction

This paper presents ontology engineering (OE) at the conceptual level, based on case analysis where an author (a human or software agent), assisted by an ITS authoring system, needs to select an instructional strategy in order to develop a learning scenario or environment. In this case the author benefits from having access to the theories on which such strategies rely. A poster will illustrate our development process at the conceptual level, which follows MizLab's view of OE [1]. Results of this process are presented in this paper, including: 1) a use case; 2) an ontology; and 3) models of the learning scenario. Furthermore, key questions raised during this process are shared for further reflection.

1. Ontological engineering at the conceptual level

In our conceptual development process, we closely followed OE methodological guidelines provided by MizLab [1], although ad hoc elements developed within the process were also necessary. The conceptual level we speak of corresponds to Mizoguchi's "level 1" [1]. The level 1 methodology should be seen as the articulation of a world of interest, and consists in: the structuring of a collection of terms; the elicitation of concepts; the constitution of a so-called "*is-a*" hierarchy among these; the establishment of brief concept definitions; and the establishment of simple relations to prevent unexpected interpretations of concepts. This conceptual development was conducted using Hozo, an Ontology environment developed at Mizlab, composed of an ontology editor and an ontology and models server.

1.1 Use-cases

In the first step, we built use cases by anticipating a situation where an author needs an instructional strategy to design a learning scenario or environment. In order to achieve his goal, the author would like to query an ITS authoring environment about the instructional theories on which the available strategies are based. Theses queries depend on learning conditions previously identified. To expose the dependency between theory and strategy, we rely on work found in a book edited by Reigeluth [2] in which alternative lessons for the same content are presented according to various theories and authors.

1.2 An iterative modelling process

As mentioned, our guidelines for this stage were those suggested by Mizoguchi [1]. He proposed that one should: 1) thoroughly investigate the "world" one wants to represent, and even aspects which appear self-evident; 2) uncover hidden assumptions; 3) formulate and formalize fundamental concepts; 4) formulate and formalize relations among concepts. Following these guidelines enabled us to uncover concepts that are implicit to various instructional theories. Then, by defining a common vocabulary for other concepts that were not in the theories, ontological commitment was taken in order to share an understanding of the world of interest among team members. Concepts were then organized under hierarchies by first identifying "*is-a*", and then "*part-of*" relations. The "*Is-a*" hierarchy organizes concepts from the abstract to the concrete. The "part-of" hierarchy allows the elaboration of more semantically complex relations that are sometimes necessary to express a concept correctly. After constituting these hierarchies, simple connectivity between concepts was established with the "*participate-in*" relation. A good explanation of these relations can be found in [3]. Again following Mizoguchi, this stage was an iterative one, which stopped once the concepts were stabilized. Only then did we start creating models (or instances). We should also mention that, with regard to the present work, level 1 was specified without any axiomatic constraints.

2. Presentation of the results

As a result of this OE process, we have built: 1) use cases to illustrate an instructional scenario for teaching a concept in optics to secondary school learners; 2) a core ontology; and 3) three models. The use cases are based on: the Gagné-Briggs Theory of Instruction, the Merrill Component Display Theory and the Collins Theory of Inquiry Teaching. In each use case, the author is presented with learning situation elements that correspond to one of the three theories. (Types of elements include: prerequisites of the lesson, learning content, the teaching strategy, teaching material, the type of assessment, and the activities involved in achieving the lesson objective and assessing learners.) For example, activities suggested to the author are based on either the Gagne instructional events, the Merrill performance/content matrix, or the Collins instructional techniques. The ontology developed at the modelling stage, which we call the core ontology, consists of a representation of a partial domain of (secondary school) optics and three kinds of learning scenarios (see figure 1). Three models that rely on the use cases and the core ontology were built. These models focus on the teaching/learning interaction, according to each instructional theory. As examples, we will present six of the nine Gagné events of instruction, one of the sixteen elements of the Merrill performance/content matrix and six of the ten Collins techniques of instruction.

3. Issues for further reflection

A number of issues were raised which would deserve further deep thinking and discussion for further work, among which are the following: 1) Are we allowed to harmonize terminology belonging to different theories or even different paradigms? 2) Is it risky to integrate elements from different theories into a single scenario? 3) Should a learning scenario be inextricably linked to an instructional theory? That is, can we use the hierarchy of Gagne's intellectual skills to represent knowledge associated with an intellectual task, no matter the theory on which the strategy is based? 4) Should we consider using test queries (via the ITS) to help validate the formalized ontology (at level 2) – and how can we evaluate feasibility at the functional level (level 3)? 6) Concretely, what could ontological engineering bring to existing ITS authoring systems [4]?

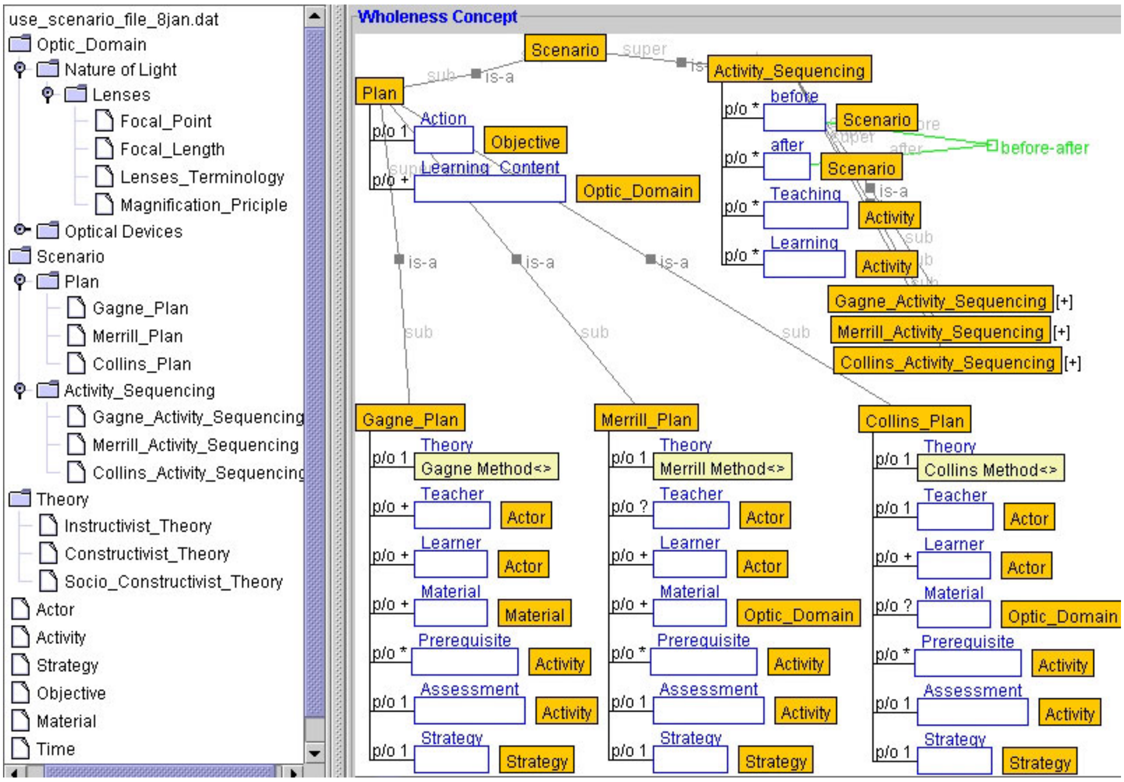

Figure 1. Core Ontology in tree hierarchy window (left) and graphical representation window (right)

4. Conclusion

We have presented the iterative process applied by team members and the results obtained at level 1. Further work will include: 1) Developing more ontologies according to theories from each paradigm; 2) Interfacing these ontologies with an existing authoring system, and experimenting with a complete scenario; 3) Developing functionalities for authoring tasks based on "2)"; and 4) Conducting an evaluation process.

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