Chapter 5.14
Orchestrating Ontologies for Courseware Design

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ABSTRACT

This chapter presents an approach aimed at creating teaching strategies for e-learning based on the principles of ontological engineering and cognitive psychology. The proposed framework is important for many reasons. It is targeted at the development of methodologies and related technologies that can scaffold the process of knowledge structuring and orchestrating teaching ontologies for courseware design. The orchestrating procedure is the kernel of ontology development. Ontologies that describe the main concepts of exemplary domains are used both for teaching and assessment techniques. The main stress is put on using visual techniques of mind-mapping and concept mapping as a powerful mind learning tool. Cognitive bias and some results of Gestalt psychology are highlighted as a general guideline. The ideas of balance, clarity, and beauty are applied to the ontology orchestrating procedures. The examples are taken mainly from the course in C-programming, and in the foundations of intelligent systems development.

INTRODUCTION

During the last decade, visual knowledge representation has become one of the key considerations in e-learning methodology and it is heavily associated with ontology design and development.

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Alongside this, so-called teaching and learning ontologies have arguably come to play a central role in courseware content. These ontologies, which are built on conceptual skeleton of the teaching domain, might serve various purposes such as better understanding, knowledge sharing, and collaborative learning, problem solving, seeking advice, or developing competences by learning

from peers. Recently, ontological engineering perspective has gained interest in the domain of computer-aided learning and cognitive psychology involving the study of the structure and patterns of knowledge. These studies rely heavily on theory and tools from knowledge engineering analysis that has already a longstanding tradition in the knowledge-based systems domain (Mizoguchi & Bordeau, 2007). The tools and techniques developed in this domain can be applied fruitfully in the field of learning structuring and design (Schreiber, 2000; Knight, Gašević & Richards, 2006), SemanticWeb applications (Davies *et al.,* 2002). The ideas of using ontologies and visual structuring in educational e-learning were discussed in many works (Davies, 20008; Gavrilova et al., 2003) and now are implemented in several software tools**.** These techniques can be used as the assessment tools also.

Ontological engineering can also be used as an effective research instrument to study how the structure and patterns of the domain knowledge are related to other course content pieces such as hands-on tasks, quizzes, exercises, and slideshows or data repositories. Much of the research so far has focused on a limited number of formal representations that are typically easy to be developed while cognitive and methodological issues are rather underestimated. Furthermore, categorization and laddering as the creative synthesizing activities also did not receive much attention in e-learning while they proofed their importance in socio-technical and management research.

Regardless of how ontological engineering is used, in all cases it is necessary to analyze the design procedure. This is typically done using interviews with the students and teachers which is a labor intensive task. The described ontologies were designed and orchestrated for the courses on knowledge engineering delivered by the author in face-to-face and e-learning formats in Graduate School of Management at Saint-Petersburg State University, the School of Computer Science at St.Petersburg State Polytechnic University (both Russia) and University of Milano (Italy), the ontologies for the C-programming course were developed for the course of Dr. Peter Brusilovsky in School of Information Sciences and Libraries at University of Pittsburgh (USA) together with his PhD students.

This chapter traces the cognitive foundations of educational design using the methods of structured ontological engineering. The purpose of the described methodology is to provide teachers and learners with the distinct recommendations in ontology design and orchestrating for better knowledge transfer and sharing.

BACKGROUND

The idea of using visual structuring of information to improve the quality of student's learning and understanding is not new. For more than twenty years concept mapping (Sowa, 1994; Jonassen, 1998; Conlon, 1997) has been used for providing structures and mental models that support the process of teaching and learning. As such, the visual representation of general domain concepts facilitates and supports student understanding of both substantive and syntactic knowledge. Many teachers, especially those who teach sciences and engineering courses, operate as a knowledge analysts or knowledge engineers by making visible the skeleton of the studied discipline and showing the domain's conceptual structure (Kinchin, 2006). Often this structure is called "ontology".

However, ontology-based approach to knowledge representation in pedagogy is a relatively new development. Ontology is a set of distinctions we make in understanding and viewing the world. There are numerous definitions of this milestone term (Neche et al, 1991; Gruber, 1993; Guarino et al, 1995; Gomez-Peres, 1999). Together, these definitions clarify the ontological approach to knowledge structuring while giving enough freedom to open-ended, creative thinking. So, for example, ontological engineering