# Let's Automate! Making Use of a Learning Ontology for Conceptual Data Modelling

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**Abstract.** Conceptual modelling education remains a challenging pedagogical task, where time investment in the development of materials, as well as providing feedback and assessing the student works is particularly high due to the ill-structured nature of the problems typical for the discipline. A growing number of students in software and enterprise engineering courses and the general digitalization of the higher education, including the shift to blended and distance learning, require an update of the existing methods and tools for conceptual modelling education. One of the possible solutions to these issues could be systematization and automation of various aspects of conceptual modelling courses, depending on the needs of a particular educator and the target audience.
In this paper, we describe the steps of development of a learning ontology for conceptual data modelling, define its structure and elements and provide examples of its possible use for systematization and automation of conceptual modelling pedagogy. The learning ontology is aimed at facilitating the structuring of learning materials and provision of feedback to students for university-level and industry-level educators, both in the traditional and in blended/online learning settings.

**Keywords:** learning ontology, conceptual data modelling, conceptual modelling education, automation, e-learning.

## 1 Introduction

Teaching conceptual modelling is commonly viewed as a challenging task requiring substantial creativity, time investment and high-level pedagogical skills. This task becomes even more challenging as often conceptual modelling courses lack clearly defined learning outcomes and course structure [1], which are essential for students' success in the course [2].

One of the possible aids to conceptual modelling educators could be the introduction of a learning ontology for conceptual modelling. Ontologies have been applied in various educational settings for many decades – even if the ontologies applied in classes were never defined as such, and were not used explicitly [3]. However, recently, ontologies – specifically, learning ontologies – are mostly mentioned in relation to e-learning design, and, in particular, feedback automation and intelligent tutoring systems (ITS) development [4]. Learning ontologies are used for multiple pedagogical tasks aimed at automated personalization: building a personalized learning path [5], providing personalized feedback in an online course [6], as well as design tasks, such as development of an e-learning system [7] or an authoring tool for building an ITS [8].

In this paper, we propose a learning ontology for conceptual data modelling, which aims to provide practical help to conceptual modelling educators for course design and automation of various aspects of the course – both in a traditional and in a blended/online learning setting, thus the ontology can be viewed as multi-purpose. The proposed learning ontology is an extension of a previously developed CaMeLOT educational framework for conceptual data modelling [9], and incorporates not only the learning outcomes, but the entire set of learning elements, such as learning items, errors, feedback items, and their interconnections. To validate the ontology in a first design round, its instantiation for the subdomain of 'creating class diagrams' is performed to assess its quality as an aid for course design and feedback automation.

The preliminary version of the ontology was applied earlier this year in an enterprise modelling master level course for generation of personalized feedback reports to students [10]. The ontology presented in this paper takes into account the lessons learned from this very first application.

This paper will describe the process of ontology development, the structure of the ontology and its elements, and provide examples of its possible uses, both for a traditional and e-learning course setting for a conceptual modelling course.

## 2 Development of a learning ontology for conceptual data modelling

To define the learning outcomes addressed in various courses on conceptual data modelling, an analysis of a set of educational materials (books, MOOCs and exam questions from several universities) was conducted [1] and the existing gaps in the existing learning materials were identified.

To further systematize the learning outcomes and provide a structured educational approach to creating and evaluating learning material, the CaMeLOT educational framework [9] was created based on the revised Bloom's taxonomy of educational objectives [11] and the study of educational materials on conceptual data modelling from a variety of sources [1]. In the ontology proposed in this paper, CaMeLOT is utilized for Learning Outcome classification and defining Learning Outcome Sets.

The structure of the proposed learning ontology is provided in Fig. 1, along with the suggested attributes for its classes. The ontology consists of the following key elements:

*Content Section*: a section of a structured course.
<u>Example</u>: Chapter 4 of the course book [12], "The Existence-Dependency Graph"
*Domain Concept*: a concept related to modelling and taught in the course.
<u>Example</u>: the Domain Concepts covered in Chapter 4 are: existence dependency, class, attribute, instance, association, consistency, multiplicity, life cycle.

*Learning Item*: a piece of learning material. This class has two subtypes: *Content Item* (a lecture, a textual chapter of the book, a video, a presentation) and an *Exercise Item* (practice exercise, test, quiz). *Exercise Item* is a type of material that requires application of knowledge by the student, while in a *Content Item* the main focus is on the acquisition of new knowledge.

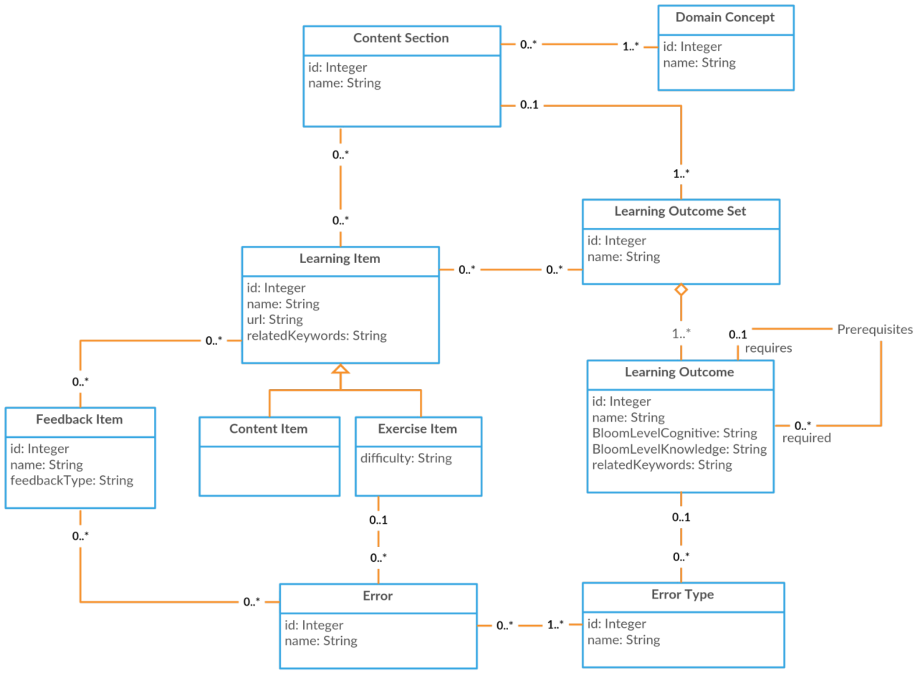


**Fig. 1.** Learning ontology UML schema

<u>Example</u>: content item: a video explaining UML aggregation and composition; exercise item: a quiz on UML aggregation and composition.

*Feedback Item*: a hint, a suggestion, an appraisal or another type of feedback message provided to the student, in either a traditional or an e-learning setting. *Feedback Items* can be specific to the *Learning Items* they address or reused in multiple learning items, both Exercise and Content items.

<u>Example</u>: a feedback message "The multiplicity on the side of class %Name% should be optional".

*Learning Outcome*: an atomic learning outcome characterized by certain knowledge and cognitive levels of the revised Bloom's taxonomy (following CaMeLOT). Each learning outcome can serve as a prerequisite for a number of other learning outcomes to enable building learning paths.

<u>Example</u>: the students should be able to distinguish between classes, instances and events; to identify and eliminate synonyms from the requirements document.

*Learning Outcome Set*: a set of learning outcomes necessary for mastering a particular content section.

Example: a set of learning outcomes related to procedural knowledge on class elicitation.
*Error Type*: a general error type that can appear in student exercises. An error type is always related to a particular learning outcome, so by the error type it is possible to understand which learning outcome has not been achieved.
Example: "missing class", "lack of a meaningful name".
*Error*: an error specific to a certain Exercise Item.
Example: "missing class A" or "lack of a meaningful name for association A_B".

A more complete example is provided through the prototype of the learning ontology populated with instances based on [12] as a course book and can be found here[1].

## 3 Using the learning ontology

We call this ontology "multi-purpose", as it can be applied in various learning settings. Here are some examples of the possible applications:

- Systematizing or automating student work assessment and feedback provision

In a traditional learning setting, the ontology can be used for systematizing and automating the grading and feedback provision to the students. In [10], we describe the first application of the learning ontology for generation of elaborative personalized feedback reports on student homework. According to the survey, the generated reports were highly appreciated by the students and the vast majority of the recipients indicated that they would wish to receive similar learning reports for other subjects they learn in their Master program.

- E-learning course or an intelligent tutoring system design

Learning ontologies are widely used in ITSs and e-learning courses teaching various disciplines. The learning ontology for conceptual data modelling could serve as a basis for designing or restructuring an e-learning course in the field of software engineering.

- Learning dashboards

Thanks to clear interconnections between various elements of a course structures using the learning ontology, it will be possible to build learning dashboards both for increasing self-awareness in students and provide necessary statistics to the teacher. Such dashboards could indicate the achieved learning outcomes, error statistics, suggest exercises related to a certain error type, etc.

- Structured learning material repository

Based on the ontology, it would be possible to build a structured learning material repository for inner use at the university or for use by the entire modelling community. Such a repository would give an opportunity to the educators to access, reuse and add

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various types of learning content, see the possible student errors and options for feedback.

## 4 Conclusion and future work

In this paper, we presented a multi-purpose learning ontology for teaching conceptual data modelling. The structure of the learning ontology could be used not only for conceptual data modelling education, but can be generalized and extrapolated to other disciplines. In the future, we are planning to continue applying the ontology for automation of feedback, explore various rules for determining student achievement of learning outcomes and ensuring appropriate feedback provision, as well as validate and evaluate the ontology "in the field" by creating an aid tool for assessment of student models.

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