



Report WP3: A1

Core textbook
content preparation:
Ontology schema for preparing the
core textbook content



Result

Ontology schema for the preparation of the core textbook content

Related to

WP3-A1: Ontology schema for preparing the core textbook content

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1. Introduction

WP3 is divided into 4 main Activities (A1-A4). This report comprises the information associated with the work done for the first activity A1, namely the "**WP3-A1: Definition of the ontology schema for textbook content preparation**".

The University of Pisa (UNIPi) is the leading organization and coordinator for this work package.

The textbook content includes the traditional textual content, tables, images, charts, diagrams, etc., and is based on the ontology schema. The developed ontology schema defines basic terms and relations between terms which enables a semantically rich description of the textbook content. The content is prepared using the support computer tools which is also defined in this work package. The content is enhanced by additional content not included in the original textbooks and by new multimedia formats and improved pedagogical approaches that serve to increase the attractiveness of the subject fields.

In this activity the state of the art of ontology mapping in education is reviewed in conjunction with the acknowledged pedagogical theory of Constructive Alignment (CA), a pillar of the TET project. Based on the results of this state-of-the-art review, the CONstructively ALigned (CONALI) ontology emerged as the most aligned for this project, although modifications were necessary to meet the TET project's requirements. The state-of-the-art review of the ontology in the field of education is reported in Section 1.2 with specific focus on CA (briefly highlighted in Section 1.1) and recapping the main requirements for TET in Section 1.3.

The following Table 1 summarizes the main acronyms in alphabetical order, full name and short description.

Table 1: Acronyms, full name, and short descriptions

Acronym	Full name	Short description
ATs	Assessment Tasks	In the Constructive Alignment framework, assessment tasks are not isolated evaluations but are purposefully linked to the specified Intended Learning Outcomes (ILOs). They serve as a means to verify whether students have successfully achieved the learning objectives set forth in the curriculum.
CA	Constructive Alignment	Constructive Alignment (CA) is a pedagogical theory and framework developed by John Biggs that emphasizes the importance of alignment in the design and delivery of educational experiences. The key components of constructive alignment include Intended Learning Outcomes (ILOs), Teaching and Learning Activities (TLA), and Assessment Tasks (ATs). The theory posits that for effective learning to occur, these three components must be closely aligned to ensure coherence and transparency in the educational process.
CONALI	Constructive Alignment Ontology	The CONstructiveALignment (CONALI) ontology, is a recent application of ontologies in education, specifically in the context of Constructive Alignment (CA). Developed using the Ontology Web Language (OWL), CONALI provides a framework to represent the body of knowledge related to CA, encompassing semantic relationships in a computer-readable format. The last version is CONALI 2.0.
EdU	Educational Units	Low level granularity distinct modules or components within an educational program or curriculum. These units are designed to cover specific topics, themes, or skills, and they serve as the building blocks of the overall educational experience.
EGV	Educational Goal Verb	An Educational Goal Verb refers to a verb that articulates the specific actions or behaviors that students are expected to demonstrate as part of achieving educational goals. By incorporating precise verbs into ILOs, educators can better communicate the intended depth and complexity of learning, facilitating the alignment between ILOs, Teaching and Learning Activities (TLA), and Assessment Tasks (ATs) as per the principles of constructive alignment.
HE	Higher Education	Education that takes place at universities, colleges, and other institutions that award academic degrees. It typically follows the completion of secondary education (high

		school) and offers more advanced and specialized instruction. Higher education includes undergraduate and postgraduate programs, leading to degrees such as associate's, bachelor's, master's, and doctoral degrees.
ILOs	Intended Learning Outcomes	These are clear, specific, and measurable statements that articulate what students are expected to know, understand, and be able to do by the end of a course or educational program. ILOs serve as the starting point for instructional design and guide the selection of teaching strategies and assessment methods. These are made by EGV, context and content.
OWL	Ontology Web Language	Web Ontology Language is a powerful and expressive language used for representing and sharing ontologies on the World Wide Web. An ontology is a formal representation of knowledge, typically describing the relationships between entities within a specific domain. OWL is particularly designed to support the development of ontologies that enable machines to reason about information and enhance interoperability between applications.
SOLO	Structure of Observed Learning Outcome	The Structure of Observed Learning Outcome (SOLO) taxonomy is an educational framework designed to assess the levels of understanding and learning outcomes in students. SOLO taxonomy categorizes learning outcomes into different levels of complexity, providing a way to measure the depth of understanding a student has reached.
TLA	Teaching and Learning Activities	Methods, strategies, and activities employed by educators to facilitate student learning. In constructive alignment, TLAs are carefully chosen and designed to directly support the achievement of the intended learning outcomes, according to the selected EGV. The aim is to create engaging and relevant learning experiences that guide students toward the desired understanding and skills.
TET	The Evolving Textbook	Current project: development of a platform for engineering EdU representation, focusing on CA. The platform of TET requires to be built on educational ontology presenting scalability, and with alignment in content to allow collaborative update of the material.

1.1 Constructive Alignment (CA)

Contemporary education practices are shifting away from traditional methods of imparting knowledge towards a more constructive theory of learning [1]. Such a pedagogical paradigm emphasizes the significance of designing Educational Units (EdU) based on learners' activities rather than instructors' actions. Constructivist models delineate the learning process through two mechanisms: assimilation and accommodation. Assimilation involves integrating new knowledge into existing understanding, while accommodation entails the realignment of potentially incorrect or incomplete pre-existing knowledge in response to newly acquired information [2].

One practical application of this shift is known as CA, which places emphasis on the actions of learners and begins with clearly communicating the Intended Learning Outcomes (ILOs) for a particular EdU. These ILOs consist of content, context, and an Educational Goal Verb (EGV) [3]. The EGV, based on Bloom's Taxonomy [4], represents the core action that learners are expected to master upon completing the educational unit. To implement CA, the ILOs are aligned with EdU activities using the EGV. In other words, the EGV are integrated into Teaching and Learning Activities (TLAs) and evaluated through Assessment Tasks (ATs) [1].

Application of such theory has been recently proposed analysing the digitalization of engineer curricula [5] and the definition of industrial engineer archetypes [6].

1.2 Ontology Mapping in Education

The exploration of ontologies in the digitalization of learning material has been an extensive endeavor over the past decades.

The educational semantic web, initially conceptualized nearly two decades ago, remains a vibrant research area, emphasizing the benefits of an ontological approach for organizing diverse educational content types [7]. Noteworthy early works, such as OntoEdu in 2004, integrated cutting-edge technologies into an educational architecture, with a core focus on the educational ontology encompassing user adaptation, automatic composition, education service, and content models [8].

Subsequent developments introduced ontological distributed platforms and utilized the OWL language to define ontology schemas, broadening the goals beyond e-learning to encompass knowledge management systems [9,10].

Several works have delved into ontologies for education, with a notable example being the Enhanced Course Ontology for Linked Education (ECOLE). As main contribution, it delves

into the use cases and architecture of an educational platform leveraging Linked Open Data [11].

More recent works continue putting effort in the creation of electronic platform for teaching materials and the management of learning information [12,13], focusing on the development of educational ontology, which serves as a vital link between the educational domain, labour market, and personalized learning [14].

Among the reviewed ontologies, the application in education specifically using CA has been solely found in the CONstructiveALignment (CONALI) ontology proposed by Maffei et. al. (Fig.1) [15]. The adoption of such a model developed using the OWL provides a framework to describe the CA body of knowledge including all the relevant semantic relationships in a computer-readable format [15]. A step further in the adoption of ontology together with CA concepts is proposed in another work published by the same author [16]. In this more recent work, the CONALI ontology is present under a different version “2.0” of such that supports collection and analysis of big educational data from constructively aligned EdUs [16]. CONALI 2.0 model is publicly available¹. Despite the valuable contribution offered by the CONALI 2.0 ontology, it does not represent the Bloom taxonomy levels of understanding and all the related required kinds of TLA and AT available in literature such as [1]. Finally, CONALI 2.0 does not support fast indexing of the featured content and context.

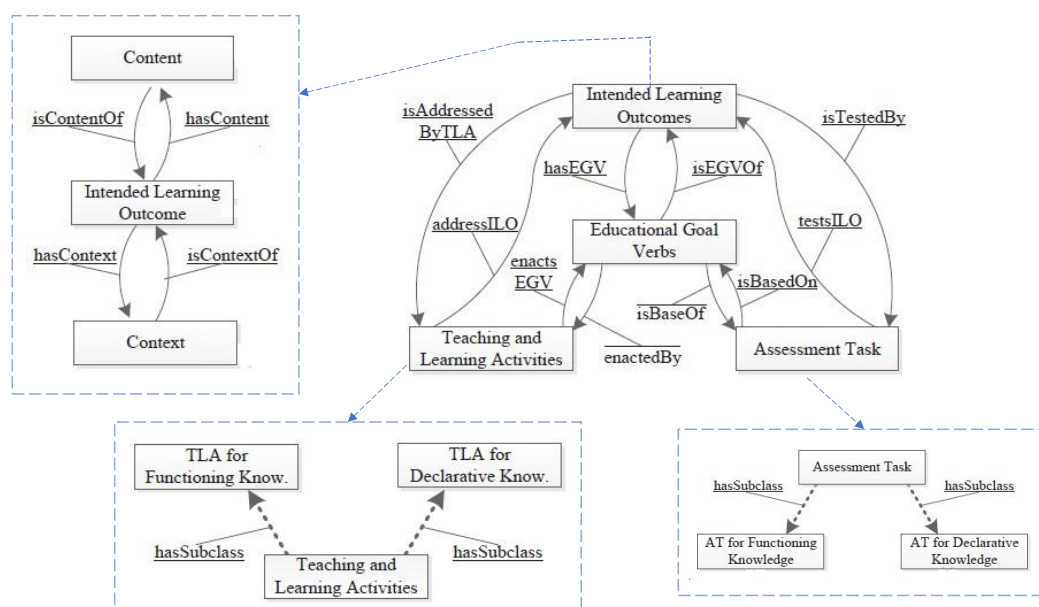


Fig. 1. CONALI ontology, classes and relations adapted from [15]. Light blue dotted lines show the lower level of granularity for ILOs, TLA and AT classes.

¹<https://unilj.sharepoint.com/:u:/r/sites/ErasmusTETproject/Shared%20Documents/WP3-Core-Textbook-Content-Preparation/WP3-A1%20Definition%20of%20the%20ontology%20schema%20for%20textbook%20content%20preparation/ConAliOntologyKTHKB.owl?csf=1&web=1&e=2ibptH>

1.3 Results

Table 2 summarizes the retrieved ontologies within the educational context, their contribution to the field and the implementation of CA.

Table 2. Reviewed papers on the application of ontology and CA for educational platforms order in increasing publishing date

Title and reference	Contribution	CA-based
The educational semantic web: Visioning and practicing the future of education [7]	Initial manifesto of education semantic web	no
Ontoedu: Ontology based education grid system for e-learning [8]	Technical and Systemic Perspective on Creating an Ontoedu from a Technological point of view	no
Exploring e-Learning Knowledge Through Ontological Memetic Agents [9]	The use of ontological representation allows for modeling personalized learning paths (PLP) that define optimal learning experiences	no
Development of an ontology-based e-learning system [10]	Proposal for Implementing Ontology to Structure Educational Material	no
ECOLE: An Ontology-Based Open Online Course Platform [11]	Promotion exchange of the educational content between universities and other organizations, and education ontology examples	no
Web Semantic Technologies in Web Based Educational System Integration [12]	Contribution to corporate E-Learning and a good review of the State of the Art	no
Ontology-based Adaptive e-Textbook Platform for Student and Machine Co-Learning [13]	Contribute to the creation of Architecture of the Electronic Textbook Platform	no
EduCOR: An Educational and Career-Oriented Recommendation Ontology [14]	Attention to FAIR principles for data management and connection between educational and occupational domains	no
CONALI Ontology. A Framework for Design and Evaluation of Constructively Aligned Courses in Higher Education: Putting in Focus the Educational Goal Verbs [15]	OWL ontology presenting constructively alignment as main design principle	yes

In TET project the focus was on the development of a platform for engineering EdU representation, focusing on CA with relance to Bloom taxonomy instead of the Structure of Observed Learning Outcome (SOLO) taxonomy and without making distinction within declarative and functioning knowledge. The platform of TET requires to be built on educational ontology to present scalability, and with alignment in content to allow collaborative update of the material.

As summarized in Table 2, despite the valuable works among the reviewed ontologies, CONALI is the only one with focus on CA, thus the best to be used in this work given the TET project requirements. However, CONALI does not exactly match the TET requirements and needs upgrade. In the subsequent activity (A2) reported in the specific document Report WP3-A2, CONALI 2.0 is modified and CONALI 3.0 is defined adding the Bloom taxonomy and removing SOLO and some redundance and not necessary information.

This effort in updating and extending existing literature (i.e., based on CONALI) instead of reinventing a new ontology from scratch represents a significant added value compared to the initial project description. It ensures continuity with previous research, supports teachers and practitioners already familiar with CA, and consolidates past developments into a coherent and synergic effort toward a more student-centred learning process as advocated by Biggs. Furthermore, the consortium has published a peer-reviewed article on this topic (*Lupi, F., Maffei, A., Podrżaj, P., Požrl, T., Stadnicka, D., Lanzetta, M. (2024). Ontology for Constructively Aligned, Collaborative, and Evolving Engineer Knowledge-Management Platforms. In: Casalino, G., et al. Higher Education Learning Methodologies and Technologies Online. HELMeTO 2023. Communications in Computer and Information Science, vol 2076. Springer, Cham. https://doi.org/10.1007/978-3-031-67351-1_10*), which provides additional scientific validation and visibility to the work performed under WP3-A1.

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