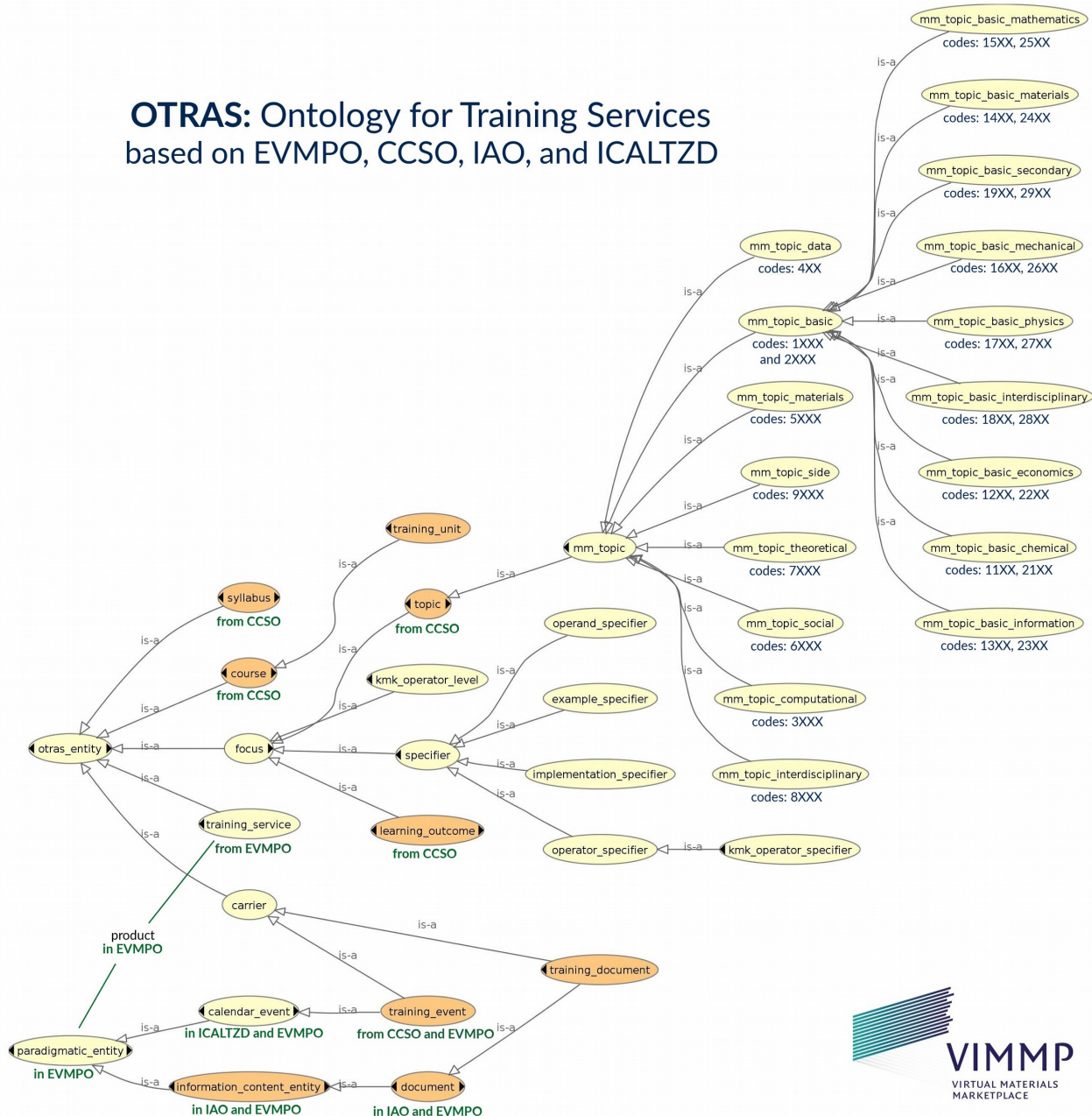


OTRAS: Ontology for Training Services based on EVMPO, CCSO, IAO, and ICALTZD



Remark: For information beyond subclass relations, refer to the TTL specification of OTRAS.

Referenced external resources and semantic assets

- CCSO: Curriculum Course Syllabus Ontology,¹ version 0.7, by Evangelos Katis.
- EVMPO: European Virtual Marketplace Ontology, internal draft document.
- IAO: Information Artifact Ontology,² by Albert Goldfain, Barry Smith, *et al.*

¹ Confer <https://vkreations.github.io/CCSO/> for further information.

² Confer <http://www.obofoundry.org/ontology/iao.html> for further information.

- ICALTZD: Ontology for iCalendars with time-zone datatypes,³ version 1.6, World Wide Web Consortium (W3C).
- KMK Operator Catalogue:⁴ Agreement of the German Federal Conference of State Cultural Ministries (KMK) for English-language learning-outcome operator designations in the natural sciences (Physics, Biology, Chemistry), version 265.

Normal form of a learning-outcome specification to be used with OTRAS

A normal form of stating a desired learning outcome can be given as follows:

“After successfully completing **X₁**, participants can **X₂** with respect to **X₃** by doing **X₄**; for example, **X₅**.” (Note: **X₄** and **X₅** are not required, and **X₁** is not a specifier of the outcome.)

Therein, **X₁** is the course or training unit for which a learning outcome is stated. The entities **X₂**, **X₃**, **X₄**, and **X₅** are the **specifiers** of the learning outcome:

- **X₂** specifies the **operator** of the learning outcome (class operator_specifier); a **catalogue of operators**⁴ with three-digit operator codes is included.
- **X₃** specifies the **operand** of the learning outcome (class operand_specifier); the operand can, and usually will, be related to one or multiple topics for which the present ontology uses the class topic, equivalent to CCSO:Topic. Within materials modelling, a **taxonomy of topics** (class mm_topic) with four-digit topic codes will be developed; in the present draft, a generic structure is already included.
- **X₄** specifies the **implementation** (class implementation_specifier), describing the way in which the competency is carried out in practice (e.g., “by writing a C++ code” or “by carrying out an appropriate series of DPD simulations”); this is optional, and no catalogue will be developed.
- **X₅** specifies an **example** (class example_specifier), explaining how the competency might be applied in a particular special case (e.g., “if asked to develop a molecular model for caffeine, the participant might suggest a rigid coarse grained model consisting of six Mie interaction sites”). This sort of specifier is also optional, it is technically only an explanation of the learning outcome.

The difference between **X₄** and **X₅** is that the implementation is a general statement on the acquired competency, whereas the example can be any arbitrary illustration of it.

³ Source: <https://www.w3.org/2002/12/cal/icaltzd>.

⁴ Developed for the use at German Schools outside Germany; source: <https://www.kmk.org/fileadmin/Dateien/pdf/Bildung/Auslandsschulwesen/Kerncurriculum/Auslandsschulwesen-Operatoren-Naturwissenschaften-englisch-03-2014.pdf>.

Operator catalogue for competency specification^{4, 5}

From the KMK catalogue:⁴

- **1XX** – Operators to be predominantly used for basic-level competencies: *Generic basic-level operator* (code **100**), “to name/label” (code **120**), “to outline/present” (code **130**), “to list/give” (code **140**), “to write a lab report/data log” (code **150**), “to sketch” (code **160**), “to draw” (code **170**).
- **2XX** – Operators to be predominantly used for intermediate-level competencies: *Generic intermediate-level operator* (code **200**), “to compare” (code **215**), “to deduce” (code **220**), “to estimate” (code **225**), “to analyse and identify” (code **230**), “to apply” (code **235**), “to calculate” (code **240**), “to describe” (code **245**), “to find” (code **250**), “to explain” (code **255**), “to describe and explain” (code **260**),⁵ “to formulate” (code **265**), “to derive” (code **270**), “to sort/group/classify” (code **275**), “to test/verify” (code **280**), “to investigate/examine” (code **285**), “to generalize” (code **290**), “to summarize” (code **295**).
- **3XX** – Operators to be predominantly used for advanced-level competencies: *Generic advanced-level operator* (code **300**), “to propose a hypothesis” (code **320**), “to evaluate” (code **330**), “to justify/give reasons” (code **340**), “to comment on/assess” (code **350**), “to prove” (code **360**), “to discuss” (code **370**), “to interpret” (code **380**), “to plan” (code **390**).

Additional operators:

- **4XX** – Operators to be predominantly used for expert-level competencies: *Generic advanced-level operator* (code **400**), “to review/evaluate critically” (code **420**), “to advise/manage” (code **425**), “to characterize experimentally” (code **430**), “to document” (code **435**), “to carry out professional work” (code **440**), “to correspond” (code **445**), “to teach” (code **450**), “to plan/project/propose” (code **455**), “to conduct an exam/assessment” (code **460**), “to systematize” (code **465**), “to expand/extend/generalize” (code **470**), “to simplify/reduce” (code **475**), “to innovate/develop” (code **480**).

Taxonomy of the topics covered by training in materials modelling

The aim here is, by the point at which the VIMMP Marketplace starts to operate, to include two fully elaborated hierarchy levels as classes, and any further categorization

5 Refer to the ontology TTL file or the KMK document for a *definition* (i.e., a more detailed description) of these operators; e.g., the operator which is *expressed by* “explain” is *defined by* giving a detailed account of causes and relationships, whereas the operator *expressed by* “describe and explain” has a *definition* that includes giving examples. These definitions, which are not always self-evident from the employed expressions, are a part of the present semantic asset on the basis of the KMK document.

that may be helpful below these two levels implemented in terms of individuals. Parallel to the taxonomy, there are four-digit codes characterizing the respective individuals.

At the first hierarchy level, the fields covered by materials modelling training are subdivided as follows (confer the TTL file for further information):

- Class mm_topic_basic (codes **1XXX** and **2XXX**): Basic prerequisites for materials modelling, including contents from undergraduate or secondary education.
- Class mm_topic_computational (codes **3XXX**): Computational and numerical aspects of materials modelling.
- Class mm_topic_data (codes **4XXX**): Data science and technology aspects.
- Class mm_topic_materials (codes **5XXX**): Topics related to materials, including but not limited to fluids, and their properties.
- Class mm_topic_social (codes **6XXX**): Social, economic, and community aspects of materials modelling.
- Class mm_topic_theoretical (codes **7XXX**): Non-computational theoretical aspects of materials modelling.
- Class mm_topic_interdisciplinary (codes **8XXX**): Topics that are best described as belonging to multiple categories at the first hierarchy level.
- Class mm_topic_side (codes **9XXX**): Topics from other disciplines that can be included as relevant side interests in materials modelling curriculum design.