Mind the Gap: Ontology Authoring for Humanists

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Abstract. Ontologies are software artefacts used for representing knowledge. The use of OWL formalisms to capture knowledge in the field of Digital Classics and Classical Archaeology is mandatory, if linking, sharing, and reusing data from multiple heterogeneous sources is to be accomplished. For the time being, the ontology authoring is out of bounds for humanists. The reason is that OWL requires having a solid background in Description Logics and more generally in Logic for Computer Science. This paper presents an alternative method and tool for ontology authoring by humanists interested in publishing the terms of their domain in Semantic Web formats. Tedi (ontoTerminology editor) is a specially-built tool that allows exporting and visualizing the resulting ontologies in Protégé. The advantage of Tedi is that it takes into account the way of thinking of humanists relying on Aristotelian definition, separating the linguistic dimension from the conceptual dimension. Based on the main idea that experts know the terms of their domain and that a concept is a set of essential characteristics, which is stable enough to be named by a term in a natural language, domain experts are then guided by the tool in defining formal domain concepts. Furthermore, it is then possible to generate patterns of definition of terms in natural language based on the formal definition of the concepts denoted by the terms. Tedi does not aim to replace existing tools, but rather complement them, while opening ontology authoring to humanists. This paper will present and illustrate this approach with an example from the field of Classics.

Keywords. Ontology, Terminology, Classics, Digital Humanities, ISO Standards

1. Ontology Authoring for Humanists in the Web of Data

The aim of this paper is to present a methodological approach to ontology editing targeted at domain experts, especially humanists (archaeologists, classicists, lexicographers, philologists). This methodology is implemented by means of a tool called TEDI, acronym of ontoTerminologyEDItor. TEDI is designed as an intelligent system to offer users support in the following tasks:

- build multilingual terminological e-dictionaries for human use;
- build conceptualizations based on a theory of concept close to the way of thinking and working of Humanities experts and of terminologists;
- represent formally specialized terms (i.e. words that express specialized knowledge in a domain);

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- build definitions of domain terms (in natural language) based on the definition of domain concepts (defined in a formal language);
- provide machine-interpretable representations to expose terms as linked data promoting interoperability.

The main idea is, first, to lower the barrier of using an ontology editing tool in order to open ontology building to a wider audience of humanists. Second, to develop the linguistic dimension of the concept system as an entry point to the conceptual model, so as to match the way experts communicate expert domain knowledge, i.e., by means of terms (they belong in language), not concepts (they are extra-linguistic).

Humanities' experts, especially those researching material culture in different cultural settings, regret the "terminological fluidity" that prevents communication [1]. When defining the terms of their field with regard to a classification of objects on the basis of their characteristics, a formal ontology, with terminological information exported in SKOS [2] and OntoLex-Lemon [3], can provide a common basis for discussion among experts, and can help them agree on the meaning of the terms they use.

Ontologies in the field of Classics and Archaeology and in the Humanities, in general, are a latecomer, as was first noted by [4]. It is even more noticeable today, that, despite the recent booming of digital technologies developed in or introduced to the Humanities, ontologies have not gained real traction with humanists. Ontologies are software artefacts used for describing and reasoning over the knowledge of an area of interest for the purpose of generation of useful metadata for indexation and semantic retrieval of Semantic Web resources. The core task of humanistic research in the age of the Semantic Web is to represent the human record for machines, too. To do this, as note in [5], humanists need to acquire the skills that will enable them to contribute to a more authoritative discussion of digital and web infrastructures. Meanwhile, as pointed out by [6], Humanities' content meets digital methods and creates projects in which the terms of production are, necessarily, set by technological constraints.

2. State-of-the-Art

Ontology building requires thorough understanding of the area of interest, which places domain experts at the core of the knowledge acquisition phase. However, it is a widespread belief among knowledge engineers that "Asking a domain expert to use an ontology-authoring tool or to understand the complexities of a description logic language (such as OWL) may result in errors or omissions, or in the expert becoming frustrated and losing interest entirely" [7]. According to [7] "the individuals with the domain knowledge are rarely versed in model or ontology development, and do not know the formal languages or logic that express ontological concepts. What is needed is to create renderings of the ontologies that fit how the experts work and make it easy for them to create, review and evolve the domain concepts." A participant in interviews conducted by [8] states the problem, as viewed by knowledge engineers, clearly: "A domain expert has to be totally convinced that ontologies are the right way of modelling knowledge in a domain, and then has to consistently work for a period of time in order to be self-sufficient. In the initial stages, when they start doing the modelling, they need a knowledge engineer to hold their hand […] the moment the knowledge engineer disappears they will not carry on with it because it's much easier to get in databases or Excel than to do all this."

These beliefs, which seem to be deep-seated, have arguably given rise to tools aiming to facilitate the involvement of domain experts by means of spreadsheet-like interfaces. The underlying hypothesis is that existing popular ontology editing tools, most prominently Protégé [9], the popular open-source ontology editor which fully supports OWL (Web Ontology Language, the Semantic Web standard for expressing ontologies) [10], are not as friendly for domain experts as they are for knowledge engineers.

Mapping Master [11], a Protégé plugin, support mapping spreadsheets completed by the domain expert to OWL "to avoid manually encoding spreadsheet content in OWL". Populous [12] provides templates with spreadsheet-style interface for the use of domain experts, thus separating both "the user from the standard ontology authoring environments" as well as "knowledge gathering from the conceptualization and axiomatization". Expert2OWL [13] integrates Excel spreadsheets as part of a pattern-based ontology development process, so that they do not have to "resort to complex ontology editing tools or even OWL syntax".

Ontology editing tools that capture the linguistic information attached to concepts via the terms are scarce [14]. Let us cite TemaTres, a Web application providing support for the management of formal representations of knowledge for thesauri and multilingual controlled vocabularies [15].

Nevertheless, most of these formal ontology systems rely on a theory of concept based on Description Logic, where concepts are defined as restrictions of roles (e.g. Protégé). This approach is far from the theory of concept used in Terminology [16] [17] and by Humanities experts, where concepts are defined as combinations of essential characteristics, and where a term is a verbal designation of a concept [16]. Unlike Protégé, TEDI is not a universal system for concept modelling. It is only dedicated to onto-terminology building, i.e. to building terminology whose conceptual system is a formal ontology, relying on essential characteristics, taking into account the way of thinking and working of domain experts and terminologists.

3. Combining Terms and Concepts

Terminology is the science of terms, i.e. specialized words denoting specialized domain knowledge [16] [17]. Terms, as defined in Terminology, interface extralinguistic knowledge and language. Ontology as a branch of Artificial Intelligence, and Knowledge Representation enables the implementation of computational models that store domain knowledge in the form of machine-understandable statements about this domain (real-world objects, events, relations). Different definitions of Ontologies highlight different views on what ontologies aim at representing. According to [18] "An [explicit] ontology may take a variety of forms, but necessarily it will include a vocabulary of terms and some specification of their meaning (i.e. definitions)." "Ontologies: Principles, Methods and Applications". According to [19] an ontology describes the concepts in the domain and also the relationships that hold between those concepts. In the context of the World Wide Web Consortium, "vocabularies define the concepts and relationships (also referred to as "terms") used to describe and represent an area of concern". But there is "no clear division between what is referred to as "vocabularies" and "ontologies". The trend is to use the word "ontology" for more complex, and possibly quite formal collection of terms, whereas "vocabulary" is used when such strict formalism is not necessarily used or only in a very loose sense" [20].

An ontologized terminology or ontoterminology is a human readable list of terms in a domain of knowledge, whereby each term is linked to the concept it denotes by means of a formal ontology [21]. There is a twofold assumption underlying this definition which comply with the ISO 1087-1 [16] and 704 [17] standards on terminology work: first, that each term is a verbal designation (denotation) of a concept, second that each concept is defined as a unique combination of essential characteristics – a characteristic is essential when removed from the object, the object is no more what it is. Essential characteristics provide criteria for subdivision in order to form classification schemes. This approach, based on delimiting characteristics [16], is also used in Formal Concept Analysis applied to building ontologies [22].

4. Building Terminology-Driven Ontologies with Tedi: Modelling the Domain of Ancient Greek Vases

When dealing with data reflecting realities of past cultures, it is important to provide definitions for terms that are as close to the described past reality as possible. To be able to build interoperable vocabularies of terms (ontologies) that describe knowledge across domains in the humanities, providing fully searchable metadata concerning the meaning (definition) of terms in these vocabularies (ontologies) is mandatory. This can also facilitate alignment between different terminologies and different conceptualizations.

4.1. Modelling Ancient Greek Vases: The Subdomain of Kraters

We set out to model the domain of ancient Greek vases. Greek vases are one of the most concrete and best known expressions of Greek civilization, contributing to better knowledge of Greek civilization, especially in all expressions of daily life. Related work includes the Kerameikos [23] ontology. The Kerameikos ontology has few classes and properties but it is populated with several individuals. In this paper we present the methodology we use for modelling the type of ancient Greek vase termed "krater". The term suggests a mixing-vessel, its etymology is from Greek kerannumi (to mix), and we know that the wine served at Greek symposia was mixed with water. According to the Beazley archive [24], one of the best sources of information or research on ancient Greek vases, in the Athenian repertoire of vases, there are four main types of kraters identified today: column-, volute-, calyx- and bell-krater. Fig. 1 shows the standard method of presentation of archaeological data: they are presented in catalogue form according to shape categories.

We modelled these four types of kraters using the following essential characteristics (called 'differences' in TEDI) organized into respective axes of analysis: for the axis of analysis of handles the differences were: /with handles/ and /without handles/. For the axis of neck the differences were /with neck/ and /without neck/. For foot the differences were /with foot/ and /without foot/. For type of handle the differences were /with column-like handles/, /with volute-like handles/, and /with upward curling handles/. An additional axis was defined for the differences /placed low on body/ and /placed high on body/ which depend on the characteristic /with upward curling handles/ (see Fig. 2).

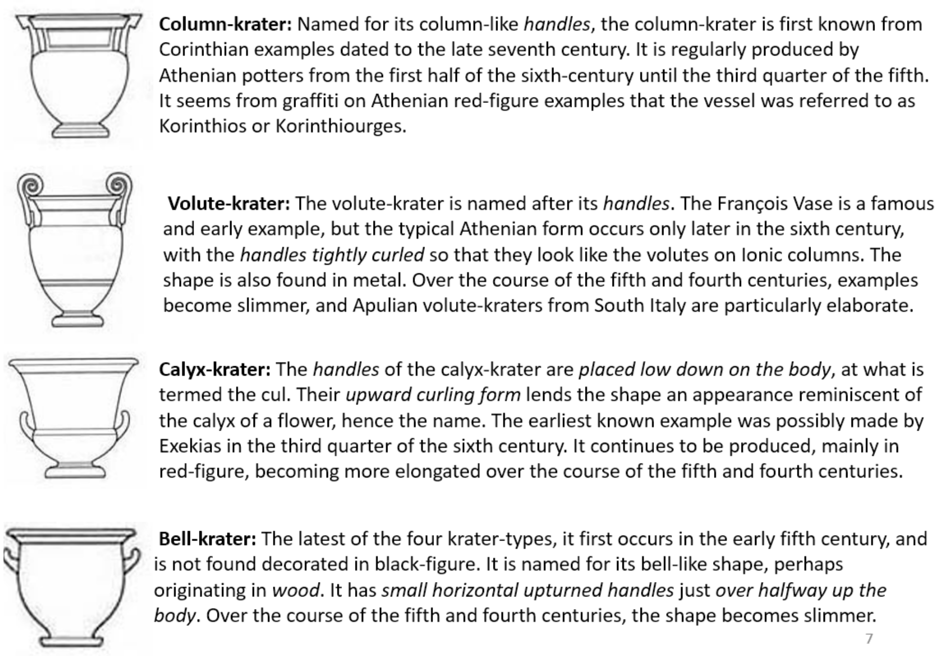

Figure 1. Standard representations of krater types [25]. Image Credits Beazley © Classical Art Research Centre 1997-2018

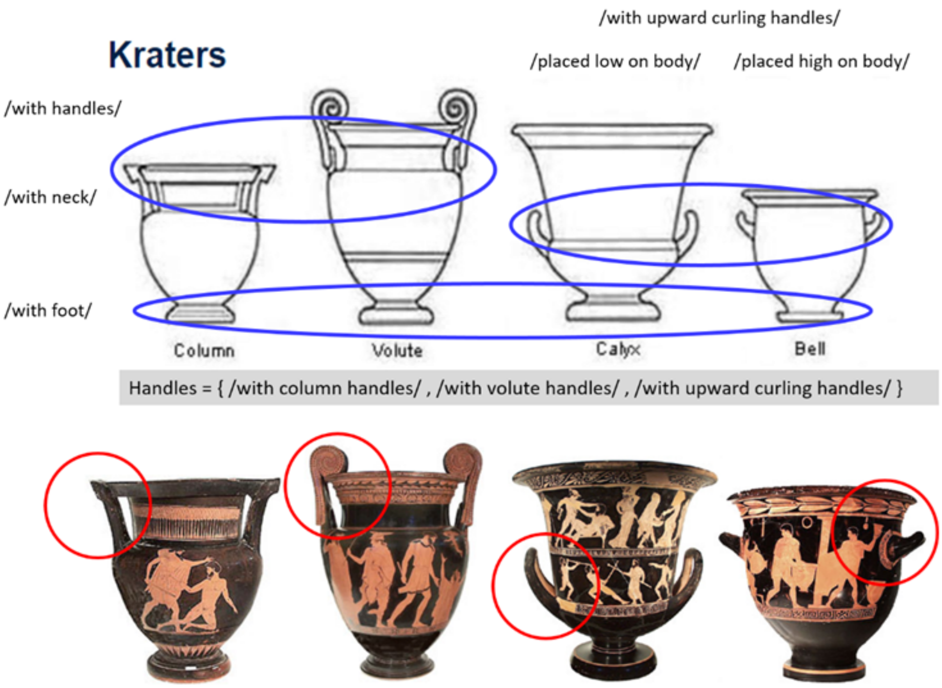

Figure 2. Modelling the subdomain of kraters. [25-29]. Image Credits Beazley © Classical Art Research Centre 1997-2018

4.2. Definition of Thing

The modelling built aims at proposing *definitions of things* (ontological definitions) [30], i.e. the definition for each term is based on the definition of the concept this term denotes. The definition of concept is Aristotelian, i.e., is based on the closest parent concept (genus) plus difference (differentia), i.e., choice among characteristics that, if removed from the object the longer is no longer what it is [31-32].

It should be noted that our modelling adopts the following conventions: to visualize the separation of the conceptual from the linguistic dimension two different colours are used (green for the former and blue for the latter); < > are used for concepts, “ ” for terms, and / / for characteristics.

In this kind of modelling, things are defined according to their essential characteristics, e.g., /with neck/ or /without neck/, with a certain type of handles and not another, e.g. a bell-krater (Fig. 3) is a krater (i.e., a vessel for mixing water with wine in ancient Greek culture). What further differentiates a bell-krater from other types of kraters is that it is a krater without neck and with upward curling handles. The concept <Vessel for mixing wine with water> is the parent concept further specified by means of the differences /without neck/, /with upward curling handles/, /upward curling handles placed high on body/ and denoted by the terms “bell krater” in English, “cratère à cloche” in French, and “κωδωνόσχημος κρατήρας” in modern Greek (Fig. 4). Tedi automatically generates patterns of definition of term in natural language. These are based on the formal definition of the denoted concept. Thus, the definition in natural language of the term “bell krater” relies on the formal definition of the denoted concept <Vessel for mixing wine with water without neck with upward curling handles placed high on the body> (see fig. 3). The name of the concept, which is not a term since they belong to two different semiotic systems, is automatically built from the formal definition of the concept and the category to which it belongs.

Tedi automatically calculated the terminological equivalents of the modern Greek term in English and French, i.e. the terms in different languages denoting the same concept.

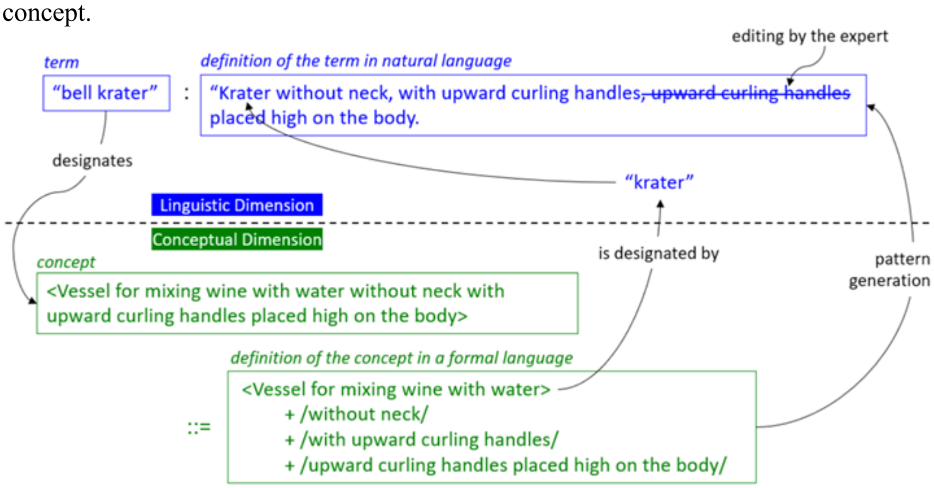

Figure 3. Definition of thing: Concept - Term definition of bell krater.

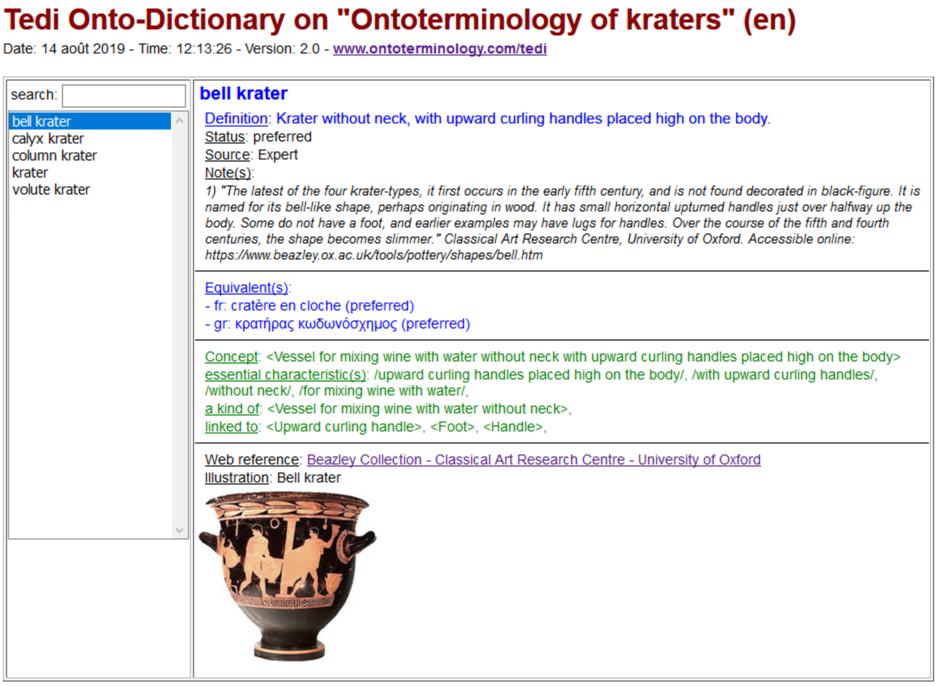

Figure 4. Definition for bell-krater in Tedi Onto-Dictionary in dynamic HTML format.

4.3. Tedi: A Set of Editors for Defining Terms and Concepts and Putting Them into Relation

Tedi [33] has been developed at University Savoie Mont-Blanc by Christophe Roche. It is available for academic projects. Tedi is a rich platform comprised of different editors, with equal user interfaces, organised in two dimensions, i.e., the conceptual and the linguistic:

Conceptual dimension:

Concept editor: The left part of the concept editor is dedicated to the display of concepts in the form of two lists. The first list displays the hierarchy of concepts according to the generic relationship (generalization/specialization), the second list in alphabetical order. Tedi supports poly-hierarchy: the same concept can appear twice in the hierarchical list since a concept can have several generic concepts. Tedi manages the inheritance of differences by the generic relationship and verifies that the logical properties associated with the differences are respected, for example, that differences belonging to the same axis of analysis are mutually exclusive or that differences can be dependent on each other (see below). For this reason, Tedi offers to the user only the possible differences when adding a new difference (reasoning and verification are done on the fly). Thus, the concept < Vessel for mixing wine with water without neck with upward curling handles placed high on the body > has as a generic concept < Vessel >, inherits the differences /for mixing wine with water/ and /without neck/, and has the specific differences / with upward curling handles/, /with upward curling handles placed high on the body/.

Axis of analysis editor. Managing concept differences and dependencies: Tedi offers two editors for the creation and editing of analysis axes and their associated differences and for the creation and editing of attributes. A concept is defined by a set of essential characteristics, called "differences", and descriptive characteristics, called "attributes" in Tedi. The axis of analysis editor is used for modelling the differences that express the nature of the objects, i.e. for the axis of analysis that we named 'Handle' we defined the following differences: /column-like/, /volute-like/, /upward-curling/. This last one was further specified into /placed high on body/ /placed low on body/ using 'Place of handle' as a dependent axis. Each axis of analysis is defined by a set of exclusive differences between them.

Attributes editor: Attributes describe the state of the object and represent descriptive, non-essential knowledge (e.g., date, dimensions). Unlike essential characteristics, attributes have values (mono-value, multi-values, of different types: string, date, literal, number, boolean). For the concepts in the subdomain of kraters the attributes defined were: date, diameter, height, material and origin.

Relations editor: Tedi allows to model any relation and their properties (functional, reflexive, irreflexive, symmetric, asymmetric, transitive) that users need to define. By default, Tedi offers the generic (isa) relation, the part-of relation as well as the following relations by default: relatedTo, hasFunction, equivalentTo, madeOf, dependentOf, sequential and causal.

Object editor: An editor for objects allows to link resources to objects like images and videos.

<u>Linguistic dimension</u>:

Term editor: Tedi term editor allows you to create and manage language-specific terms that share the same conceptualization. The terms are displayed in alphabetical order. Tedi makes it possible to associate each term with its status (choosing from: preferred, alternative, tolerated, not recommended, obsolete, none), grammatical category (part-of-speech), gender (choosing from: masculine, feminine, neuter, none), specify the spelling variations and inflected forms of the term (for terms belonging to inflected languages), as well as contexts and notes.

Multilinguality: Tedi links terminologies (linked by means of the same or aligned ontologies) in different languages. Tedi allows to edit terms in the following languages by default: English, French, Chinese, German, Greek, Italian, Portuguese, Spanish.

Proper names editor: Tedi manages proper names (e.g. the François vase, the krater of Exekias) the following statuses for proper names by default: none, anthroponyms, toponyms, ergonym, praxonym, phenonym, zoonym.

<u>Fast functionality</u>: Tedi supports users in building their term lists and concept hierarchy independently. Nevertheless, if experts know the terms of their domain, defining concepts and organizing them into a hierarchy is not so simple. The 'Fast' functionality guides experts in defining concepts. This functionality implements a methodology dedicated to building ontoterminology. The methodology relies on the main idea that a concept is a set of essential characteristics which is enough stable to be named by a term in a natural language. It means that building ontology in Tedi is guided by terms, knowing that new concepts can be introduced in order to structure the conceptual system, for example the concept <Vessel with neck>. In the example of "bell krater". Thanks to this functionality, after having selected the essential characteristics designated by the "bell krater" term, Tedi proposes to the user to create the concept corresponding to these characteristics and to insert it into the conceptual hierarchy.

One possible workflow is shown in Fig. 5 (in fact, the stages are interlinked). To fully take advantage of the fast function (step 3), which puts into relation the conceptual with the linguistic (colour coded green and blue, respectively) one possible workflow is to first enter the terms (step1), define the essential characteristics (step 2), define concepts guided by terms (step 3) which helps choose, and create if necessary, the right concept, alleviating cognitive load. Manual creation of this concept graph would by highly complex. Suffice it to say that 10 pairs of characteristics (differences) can be deployed in a concept tree of 1024 leaf concepts (2^{10}). Completing the conceptual dimension (step 4) and the linguistic dimension (step 5).

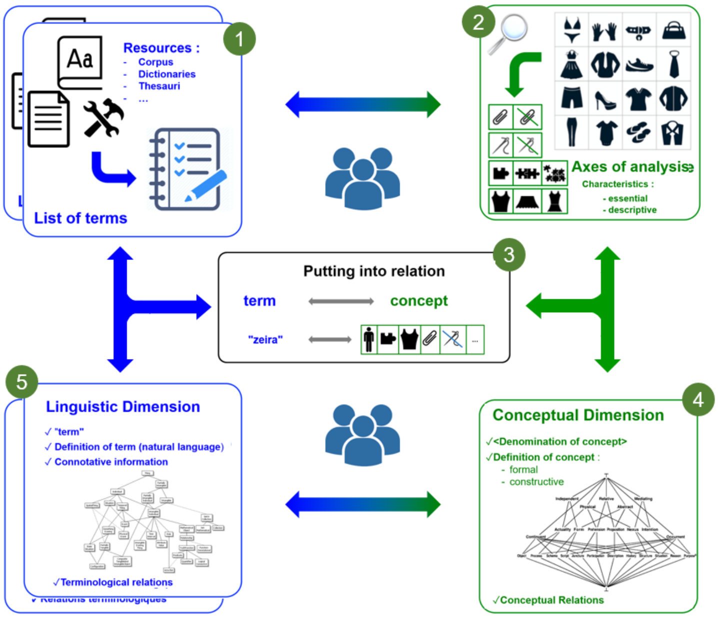

Figure 5. Tedi Tool-assisted Methodology.

<u>Generation of patterns of definition in natural language</u>:

Tedi generates a pattern of definition for each term based on the formal definition of the denoted concept. The pattern begins with the direct hypernym followed by the essential characteristics of the denoted concept. The user can modify it according to his/her needs (see Fig. 3). This functionality of Tedi is especially useful, if compared with Protégé, where the linguistic dimension is implemented only by means of labels or OntoLex-Lemon (e.g., see how terms are represented in the Kerameikos ontology).

<u>Export formats</u> include human readable and machine processible formats: dynamic and static HTML (see Fig. 4), JSON, XML, RDF/OWL in order to export and visualize in Protégé (see Fig. 6). In the case of exporting in OWL, the essential characteristics of a same axis of analysis are translated into disjoint classes, thus losing the epistemological difference between concepts and essential characteristics. Tedi also exports in CSV in order to visualize terms and concepts in the CmapTools software environment [34]. The possibility to export in SKOS and OntoLex-Lemon formats is under construction. Tedi HTML export for the definition of the term “bell krater” is shown in Fig. 4. This export format has the advantage of resembling the entry of an online dictionary that includes images and video. The visual and notation conventions

used in Tedi are also followed here: colour coding: blue for terms, green for concepts, black for status, context, and notes and contexts, < > for concepts. Future work includes visualizing part-of-speech, attributes, and relations.

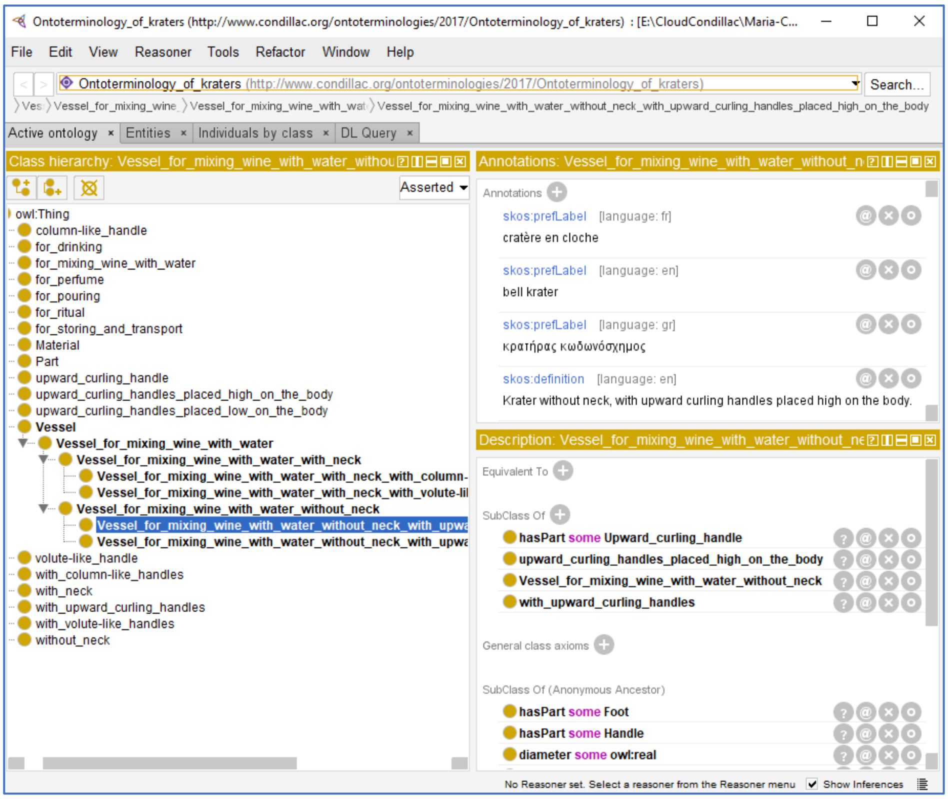

Figure 6. Tedi export of the ontology of kraters in Protégé.

5. Conclusion

Tedi, an editor for the building of multilingual ontoterminologies (i.e. term lists whose denoted concepts are structured in a formal ontology) supports users with a set of useful automations. Ontology building is guided by terms: a concept is a set of essential characteristics stable enough to be named in a language by a term. Tedi's intelligent automations include the generation of a natural language definition pattern of the term based on the formal definition of the concept denoted by the term, as well as the automatic calculation of terminological equivalents, i.e. equivalent terms denoting the same (or similar) concept in other natural languages. For interoperability purposes, Tedi exports not only in an ontology-based e-dictionary format, but also in a number of machine understandable formats, such as OWL. Tedi is based on the notion of essential characteristic on which the definitions of the concept and term in terminology work are based according to the ISO 1087-1 and 704 standards. Tedi guides the user by proposing at each step only the possible options that verify the logical properties of the conceptual system. The management of the linguistic dimension when building ontologies is often forgotten or reduced to annotations to concepts, e.g. labels. Tedi separates the linguistic dimension (terms) from the conceptual (concepts) and guides users to link concepts to their verbal designations, i.e. their corresponding terms.

Knowledge sharing can only take place if humanists agree on the terms to be used and their definition. The meaning of terms that denote cultural objects is based on knowledge of the field and more specifically on the way in which experts classify, organize and structure the objects of the world. The definition of terms referring to cultural objects is a definition of the concept to which the objects designated by the term are assigned. Clearly identifying the meaning of terms can help humanists agree on the conceptualization of their respective domain.

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