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CONALI Ontology. A Framework for Design and Evaluation of Constructively Aligned Courses in Higher Education: Putting in Focus the Educational Goal Verbs

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Abstract

An increasing number of Higher Education professionals have embraced the Constructivism theory in contrast with the traditional transmissive pedagogy approach where the focal figure is the teacher. Constructivists emphasizes that the learners acquire, or construct, knowledge through their own activities and previous knowledge. Teacher role is to set up an environment that can provide a good learning experience for the students. In view of this the alignment of the intended learning outcome (ILO) with the teaching and learning activity (TLA) and the assessment task (AT) of the course becomes an important requirement for good learning. The driver of the alignment is the educational goal verb (EGV) that represents the educational goal underling a specific intended learning outcome (ILO). This verb should be elicited by the course's TLA and be the base for the consequent AT. The convergence of constructivism with this concept generates the constructive alignment pedagogical paradigm.
The CONALI ontology answers the requirement for a structured framework to describe the vast body of knowledge developed in such a field. The salient aspects of constructive alignment have been extracted and classified in a comprehensive taxonomy. The following description of the semantic relationships among the different classes resulted in the CONALI ontology. The chosen modelling language is OWL: this provides the possibility to describe in a computer understandable way a higher education courses to an unprecedented level of detail. OWL enables also the creation of a specific knowledge base by populating the model. The knowledge base can then be analysed and interrogated on many important issues concerning the alignment of the instantiated course. The CONALI ontology becomes an important tool to design and synthesize the related domain knowledge.
This paper proves the usability of CONALI ontology as tool to represent the courses in an engineering program and evaluate the alignment of their activities. The specific instantiation is based on the Industrial Engineering program at KTH Royal Institute of Technology in Stockholm, Sweden.

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Keywords: Constructive Alignment; Ontology; Knowledge Base

1. Introduction

Constructive Alignment (hence CA) has emerged from the work of John Biggs [1, 2] as outstanding principle for devising effective and efficient pedagogical activities in higher education. In particular, CA builds upon two main concepts: the constructivist understanding of the learning process and the practical need for aligned and outcome-based curricula designing. The potential of this approach has attracted the interest of a growing community of researchers which is rapidly expanding the body of knowledge in such a domain. The following Fig. 1(a) shows the exponential growth in the number of papers indexed in Scopus and Web of Science that have as main topic CA.

The Fig. 1(b) shows the total number of documents indexed in Google Scholar which is related with such a topic every year since 2005. The growth is once again close to exponential.

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Scholars' interest is always pivotal to actual application of theories. Besides, there is a high pressure of the higher education institution around the world to acquire and use specific pedagogic knowledge that can help improving the efficiency and effectiveness of course design and execution. KTH Royal Institute of Technology in Stockholm has embraced the Constructive Alignment as a strongly recommended approach to pedagogy. KTH School of education and communication in engineering science (ECE) has been offering since early 2000's a series of courses that provide teachers in higher education with a set of tool to encourage student's reflective practice [3-5]. Over 900 KTH and external teaching personnel have been exposed to CA and similar concepts in the last decade and they implement them to different extent in their own work. KTH is not the only Swedish or international institution in the forefront of CA application. The recent Constructive Alignment Project (CAP), among many others, has driven courses improvement and renewal at Chalmers University of Technology in Gothenburg [6].

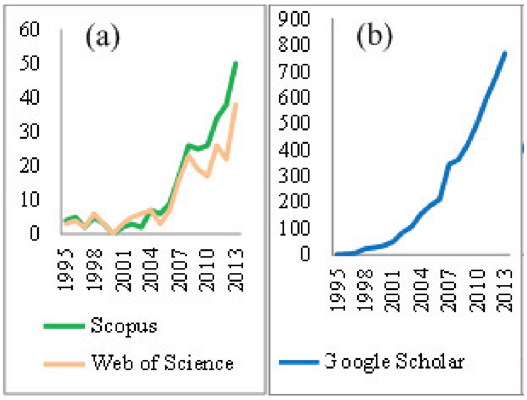

Fig. 1 (a) Annual number of paper with CA as main topic in Scopus and Web of Science; (b) Annual number of documents featuring CA in Google Scholar

The initiator of CA, John Biggs, has recently published a survey of some of the most significant contributions published lately in this domain [7].

A first result is that all the authors agree on the positive impact of CA on teaching effectiveness and efficiency. However, Biggs also pointed out how the actual implementation of CA requires, as any major teaching reform, a substantial effort from the interested institution to put in place the necessary policies and procedures. The staff workload is an utmost issue: current schedule of the average teachers leaves little, if any, space to reflective practice that can foster CA application. Resistance to change is another obstacle as many teachers feels that CA takes their teaching out of their hands: CA focuses on the role of the institution as main responsible for teaching, a view that many teachers does not share. In addition to that the rapidly increasing interest, discussed at the beginning of this introduction, presents the inherent risk of uncontrolled and diverging growth.

This paper aims at addressing these problematic areas at once by formalizing the main concepts and relations in this domain through a framework model embodied in an ontology. The following Table 1 summarizes the reasoning behind this approach by showing how the issues identified can be coupled, and thus addressed, with the potential benefits of producing an ontology as described in [8].

First reason to develop an ontology is to establish a common view on how describe a domain. This includes a common jargon and a shared way of representing the main entities, their relations and related data. The CONALI ontology is meant to be an open initiative and an iterative process that aim at synthesizing a unified view of as many stakeholders of Constructive Alignment as possible. This should channel this ramping up phase of the concept towards a solid and commonly accepted maturity. Scarcity of resources needs efficient ways of implementing and maintaining CA.

Generic ontologies can be populated with specific instances and data by users. This provides the capability of establishing, updating an analyzing a knowledge base through user-friendly computers applications.

Table 1 Problematic area of CA and connection with the benefits of producing and ontology

Problematic areas connected with CA	Benefit of producing an ontology [8]
Scarcity of Resource	- To enable reuse of domain knowledge - To analyse domain knowledge
Resistance to Change	- To make domain assumptions explicit - To separate domain knowledge from the operational knowledge
High interest and consequent risk for uncontrolled and diverging growth	- To share common understanding of the structure of information among people or software agents

The human contribution can then be supported, directed and on some extent optimized. In this context one might think of the impact of a rigorous ontological framework on some very common activities for educators such as reusing the work done for a previous course when designing a new one or spotting and targeting specific problems in educational units (hence EdU). Resistance to change can be won if one is able to see clearly the positive effects of the implementation [9]. CA must be understood and enforced completely at all the levels of the institution. This is addressed by the capability of ontologies to make domain assumptions clear and immediately visualized. This allows distinguishing between domain knowledge and operational knowledge and thus set the scene for the formulation of specific procedural knowledge. In the domain of pedagogy, the envisaged ontological framework aims at highlight the relationship between operational design choices, such as deciding the approach to teach a given concept, and the underlying pedagogical principle.

In conclusion this work aims at contributing in the following three areas:

- Produce the first iteration of an ontological framework model for design and evaluation of constructively aligned courses (Hence CONALI ontology). This model is presented in the § Results and encapsulates the salient constructs and their relationships as emerged from the pertinent literature that is briefly introduced in the § Background.

- Instantiate the defined CONALI ontology on a selected set of courses given at the department of Production Engineering at KTH Royal Institute of Technology in Stockholm (Hence KTH IIP). The result of this activity is a complete knowledge base for the given courses and it is presented in the § Case Study.
- Define and analyze some KPI connected with the alignment of educational units and interrogate the knowledge base on the performance attained by the represented courses and the areas where improvement is necessary. The KPI are introduced in the § Result and subsequently calculated with relation to the specific case study in the related §.

2. Background

Constructivists believe that individuals construct new knowledge from experiences through reflection and consequent abstraction of basic principles. Two are the processes that generate new knowledge: *assimilation* and *accommodation*. Assimilation consists of framing new knowledge into pre-existing one; this might generate misconception when the individuals try to fit new concept into a non-adequate pre-existing knowledge. Accommodation is the process reframing pre-existing knowledge based on new ones [10]. As consequence the process of learning depends on what the students do rather than simply on what teachers say. In opposition to traditional transmissive pedagogy the focus of efficient and effective pedagogy should be on the learner's perception evolution rather than on the teacher's activity. Teacher fundamental task is then to facilitate the correct evolution of the student perception of the topic.

Having this in mind Biggs devised a systematic operational framework for the design of teaching within an education unit* [11]. The CONALI ontology is heavily based on this and other related contributions that will then be presented in the rest of this paragraph. Since the aim of an ontology is describing a specific domain knowledge, one might read this paragraph as "the story" behind the ontology.

The main activities in Biggs approach to design an educational unit, are:

1. Describe the *intended learning outcomes* (ILOs) for the unit, using one verb (or at most two) for each outcome. The ILO denotes how the content or topics are to be dealt with and in what context.
2. Create a learning environment using teaching/learning activities (TLAs) that require students to engage each verb. In this way the activity nominated in the ILO is activated.
3. Use assessment tasks (ATs) that also contain that verb, thus enabling one with help of predetermined using rubrics to judge how well students' performances meet the criteria.

In other words ***the verb representing the educational goal (Hence Educational Goal Verb or EGV) must be used as common denominator for aligning ILOs, TLAs and ATs***. In particular this is useful when the respective educational goals are connected. The alignment can be based on the *nature* of knowledge and on the level of *understanding* required by the ILO. Regarding the nature, knowledge can be classified into *declarative* and *functioning*. Declarative knowledge (DK) is represented by the verbs in the semantic domain of "explain" and refers to the knowledge about things expressed in verbal or other symbolic forms. Functioning knowledge (FK) is represented by the verbs meaning "apply" and is knowledge that underpins action by the learner.

The level of understanding can be described using two non-homogenous dimensions: the level of *complexity* of the knowledge, useful to design effective assessment and the *type* of knowledge that can suggest effective learning activities. The complexity can be described with the SOLO taxonomy [12], a hierarchical model consisting of 5 increasingly sophisticated levels: Pre-structural, Uni-structural, Multi-structural, Relational and Extended Abstract. The type of knowledge is best represented through the modified Bloom taxonomy [13] featuring 6 activities that requires different type of knowledge: remembering, understanding, applying, analyzing, evaluating and creating.

3. Method

The language chosen for this endeavour is Web Ontology Language (OWL). Besides the obvious adequate support to express all the relevant entities and relationships in the domain OWL offers a high degree of interoperability due to the compliance to RDF/XML-based serialization for the semantic web. Compatibility with web standards and tools is dramatic if one considers that the CONALI ontology aims at involving as many experts in higher education as possible in the development of a knowledge base for educators that wants to work with constructive alignment.

The ontology has been edited with the open source software Protegé 4.3† : this solution offers a stable and user-friendly platform and a vast community of users and developers. Protegé is now also available also in a fully online version. The availability of many third open source semantic reasoners that can verify the consistency of the model in parallel with the creation is also an appreciated feature that simplifies the modeling phase: CONALI ontology's classes and related properties have been checked with the reasonner FaCT++‡ for coherence.

The ontology has been manually populated with data mined from available documentation related with examined courses and brief sections of direct interaction with KTH IIP teaching staff. The consequent creation of a KTH IIP CA knowledge

* Education unit can be a course or an independent module or part of a course.
† http://protege.stanford.edu/
‡ http://owl.man.ac.uk/factplusplus/

base has made available a significant set of data that have been interrogated to devise the current holistic and detailed performance of the described educational units.

The measurement of constructive alignment presented in this paper shares some of the reasoning behind the work of Tepper [14]. This author proposed a framework based on Set theory and linear algebra for holistic and individual aspects of this task. The method uses Bloom's taxonomy as basis for categorizing the components of a teaching system and some basic principle of generative linguistics to represent the alignment structures. In principle, CONALI ontology supports this approach by presenting some of the required alignment structures and data in a computer usable way. However at this stage of development the focus has been more on the ontology itself than on the intended synthetic use; thus, evaluation of the proposed case study has been based on two simplified metrics: (1) the alignment of TLA and AT to the related ILO through the specific EGV and (2) the coherence of TLA and AT with the addressed kind of knowledge (declarative or functioning). A formal definition of the metrics is presented in the following § Results. The base of analysis for this work is the educational unit. Practically an EdU can be a course or an homogenous subset of a course.

Finally, it is important to discuss some of the inherent limitations of this work. Like any ontological model CONALI ontology represents a subjective view on the analysed domain. Different authors might have been designing it differently. What is important in designing an ontology is to keep in mind the use and the type of questions one might want to have answer to [8]. Moreover, building ontologies is an iterative process. This work presents only a first step toward a usable tools that must be necessarily designed bringing in more aspects and experiences. The use of open source software like Protégé aims at involving in the CONALI ontology open project a significant number of scholars and practitioners that can form a unified jargon and understanding of the domain.

4. Results

The two main building blocks of this first iteration of the CONALI ontology are the classes, representing the key objects in the domain and the object properties which describe the relations among such objects. In this work the ontology sematic is represented with a structured sentence built as follow: <**Class X**> <*Object Property Y*> <**Class W**>. Both entities are enclosed in chevrons; classes are written in bold font and object properties in italics.

Biggs describes ILOs as composed of three elements: and Educational Goal Verb that identifies the action required for the student by the focal educational unit, a Content that represents the object of the EGV and a context that constrain the resulting predicate to a specific domain.

The CONALI ontology representation of this concept is introduced graphically in Fig. 2 and detailed as follows:

- Link ILO-EGV
  - <**ILO**> <*hasEGV*> <**EGV**>
  - <**EGV**> <*isEGVOf*> <**ILO**>
- Link ILO-Content
  - <**ILO**> <*hasContent*> <**Content**>
  - <**Content**> <*isContentOf*> <**ILO**>
- Link ILO-Context
  - <**ILO**> <*hasContext*> <**Context**>
  - <**Context**> <*isContextOf*> <**ILO**>
- Link EGV-Content
  - <**EGV**> <*hasObject*> <**Content**>
  - <**Content**> <*isObjectOf*> <**EGV**>
- Link EGV-Context
  - <**EGV**> <*hasDomain*> <**Context**>
  - <**Context**> <*isDomainOf*> <**EGV**>

The basic concept behind CA is the desired alignment between ILOs, TLAs and ATs related to a specific educational unit. This alignment is based on the use of the focal EGV for all the activities connected with the ILO featuring that particular EGV. The CONALI ontology describes this critical aspect by introducing a double loop of relations among the key concepts in the domain.

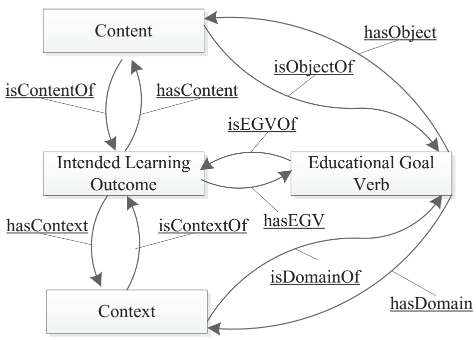

Fig. 2 Relationship between ILO and its constitutive parts

The first loop is linking directly the ILO with the envisaged TLAs and AT and it is constructed as follows:

- Link ILO-TLA
  - <**ILO**> <*isAdressedByTLA*> <**TLA**>
  - <**TLA**> <*addressILO*> <**ILO**>
- Link ILO-TLA
  - <**ILO**> <*isTestedBy*> <**AT**>
  - <**AT**> <*TestsILO*> <**ILO**>

The second loop uses the EGV as intermediate concept to embody the operational aspect of the same alignment, as described by Biggs. In detail:

- Link EGV-TLA
  - <**EGV**> <*enactedBy*> <**TLA**>
  - <**TLA**> <*enactsEGV*> <**EGV**>
- Link EGV-TLA
  - <**EGV**> <*isBaseOf*> <**AT**>
  - <**AT**> <*isBasedOn*> <**EGV**>

The following Fig. 3 provides the graphical representation for these concepts in CONALI ontology

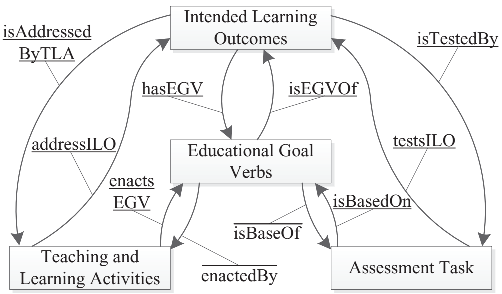

Fig. 3 Principle of constructive alignment in CONALI ontology: Educational goal verb as common denominator among ILO TLA and AT

The second operative loop allows defining a metric for the course alignment. In particular good alignment means having an effective EGV that describes a precise action and using this verb across the related TLA and AT by following the logic depicted above. The Table 2 introduces the possible scenarios in relation to a specific EGV.

Table 2 Scenarios associated with alignment of ILOs, TLAs and ATs through a given EGV and related proposed scores

Scenario	Score
EGV does not indicate a learner action	0
EGV indicates a learner action	
Partial alignment	
• $EGV_{ILO} = EGV_{TLA}$ and $EGV_{ILO} = EGV_{AT}$	3
• $EGV_{ILO} = EGV_{AT}$ and $EGV_{ILO} = EGV_{TLA}$	
Perfect Alignment	9
• $EGV_{ILO} = EGV_{TLA} = EGV_{AT}$	

EGV_{ILO} is the educational goal verb of a specific ILO. If this verb is not addressing a specific action of the learner is not suitable for constructive alignment. Typical example is the verb “understand”. When the EGV_{ILO} is properly choose then it is possible to compare it with the related TLA and AT. In particular if the TLA “enacts” the same verb (EGV_{ILO} = EGV_{TLA}) and the AT “is based” on such a verb (EGVILO = EGV_{AT}) then the alignment is perfect and creates good learning environment. Intermediate scenarios can be considered partial alignment and results in a significant reduction of the effectiveness of the education effort. The scale used for the scoring is exponential. This assumption reflects the multiplicative effects of mutual reinforcement that coherently designed activities can achieve through CA. When a specific knowledge base in created by populating the CONALI ontology is possible to collect the score for each EGV in the educational unit. Biggs recommend using, when necessary, ILOs featuring more than one EGV and specific object and domain. This is why the single data point corresponds to an EGV and not to an ILO. The ratio of the sum of all the calculated scores with the theoretical maximum number of points available in the educational unit provides the related percentage of alignment. This KPI is indicated with the notation %A and is formally defined in equation (1) as:

$$\% A_{EdU} = \frac{\sum_{0}^{V} EGV_i score}{9 \cdot V} \quad (1)$$

Where V=#EDV in EdU. It is important to notice that this is an aggregated KPI that can be decomposed into the single contributions of each EGV in the educational unit in exam. This allows diagnosing the specific reasons of low alignment both for the single EGV as

$$\% A_{EGV} = \frac{EDVscore}{9} \quad (2)$$

or for the ILO as

$$\% A_{ILO} = \frac{\sum_{0}^{I} EGV_i score}{9} \quad (3)$$

Where I = #EDV in ILO

Fig. 4 describes how CONALI ontology connects ILOs with DK and FK through a specific superclass called kind of knowledge.

The CONALI ontology classifies TLA and AT on the basis of their target kind of knowledge. Different objectives require different TLAs and ATs. TLAs and ATs for functioning and declarative knowledge must reflect the structural difference among them. One cannot assess the ability of someone to drive by a multiple choice questionnaire, or the knowledge of traffic laws by test drive.

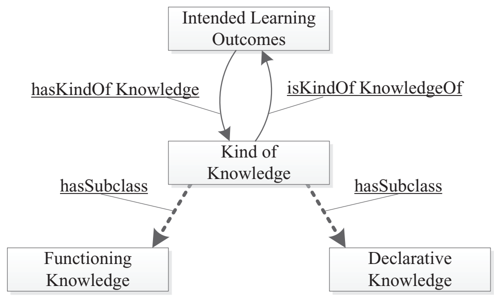

Fig. 4 Relationship between ILOs and Kind of Knowledge and related taxonomy

The subsequent Fig. 5 details this aspects and if read together with Fig. 2 explains how this concept is modelled in the proposed framework and how it reinforces the alignment of TLAs and ATs with the subclasses of Kind of Knowledge and thus with the ILO.

The CONALI ontology explicitly couples TLAs and ATs with the suitable kind of knowledge. This is aimed at revealing if an educational unit implements suitable teaching and learning activities and assessment tasks for the intended learning outcomes. In other words, situation where a course promises an ILO like “the student will be able to operate a robot in industrial welding installation” by following some lectures, reading a book and writing essay must be spotted and avoided.

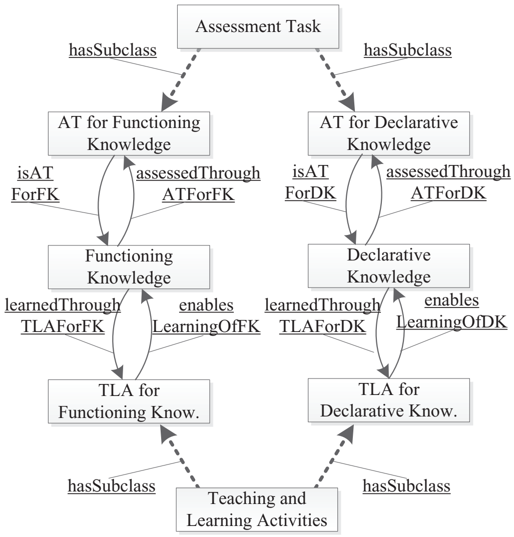

Fig. 5 Alignment of TLA and AT with the kind of knowledge in the educational unit

This modeling choice allows to integrates the analysis of the %A by indicating if specific TLA and AT are suitable for a given ILO of for one of its composing EGV. With reference to the kind of knowledge (hence KOK) it is possible to define 8 scenarios and related scores as presented in the following Table 3.

Table 3 Scenarios associated with kind of knowledge for the CA of a EGV and related proposed scores

	Scenario		
$KOK_{EGV/ILO}$	KOK_{TLA}	KOK_{AT}	Score
D	D	D	1
D	D	F	0
D	F	D	0
D	F	F	0
F	D	D	0
F	D	F	0
F	F	D	0
F	F	F	1

The ratio among the sum of these scores for ad educational unit and the maximum theoretical score result in a KPI named Kind of Knowledge Alignment and formally defined as follows:

$$\% KA_{EdU} = \frac{\sum_{0}^{V} KA - EGV_i score}{V} \qquad (4)$$

As for the %A $V = \#EDV$ in EdU and it is possible to analyze the single contributions of an ILO to the aggregate indicator through the following equations:

$$\% KA_{ILO} = \frac{\sum_{0}^{I} KA - EGV_j score}{9 \cdot I} \qquad (5)$$

Where once again $I = \#EDV$ in ILO. The contribution of the single EGV is a Boolean variable assuming value 1 for aligned kind of knowledge and 0 else.

5. Case Study: KTH IIP knowledge base

The CONALI ontology has been instantiated on 5 courses available at KTH IIP. The resulting case study covers EdU given for B.Sc., M. Sc. and 5 years engineering programs. The process of populating the ontology has involved KTH IIP staff directly connected with the analyzed courses. Table 4 provides an overview of the courses selected for this case study.

Table 4 Overview of the analysed courses

Code	Credits (1=26.7h)	Level	Av. n° of students
MG1026	6.0	B.Sc.	180
MG2100	7.5	M.Sc	45
MG2033	6.0	M.Sc	80
MG2040	6.0	M.Sc	40
MG2028	6	M.Sc	130

The following Table 5 provides a quantitative representation of the instantiation process. For each course/class pair the table shows the number of individuals introduced in the knowledge base, as well as the total figures for each course and class separately.

Table 5 Quantitative summary of the CONALI ontology instantiation

		Courses					
Individuals		MG1026	MG2100	MG2033	MG2040	MG2028	Total
Classes	ILOs	8	6	21	10	8	53
	EGVs	8	14	36	17	11	86
	TLAs	9	18	52	16	11	106
	ATs	6	6	25	3	12	52
	Total	31	44	134	46	42	297

The established knowledge base allows at this point evaluating the CA of the represented EdU. Table 6 provide a summary of the KPI calculation at course level while Table 7 puts in evidence the identified sources of misalignment identified in the analysis.

Table 6 KPI %A and %KA for the courses analyzed

Course	%A	%KA
MG1026	87.5%	87.5%
MG2100	81%	86%
MG2033	70%	69%
MG2040	80%	88%
MG2028	91%	100%

Table 7 Sources of misalignment identified by through the analysis

Course	ILO n°	Cause
MG1026	8	Non suitable EGV
MG2100	4	1. $\#1EGV_{ILO} \neq EGV_{AT}$ 2. $\#2EGV_{ILO} \neq EGV_{TLA}$ 3. $\#2EGV_{ILO} \neq EGV_{AT}$ 4. $\#3EGV_{ILO} \neq EGV_{TLA}$ 5. $\#3EGV_{ILO} \neq EGV_{AT}$ 6. $KOK_{\#2EGV}$=FK and KOK_{TLA}, KOK_{AT}=DK 7. $KOK_{\#3EGV}$ =FK and KOK_{TLA},KOK_{AT}=DK
MG2033	2	No TLA for #2EGV
	8	No TLA and AT for #2EGV
	9	KOK_{EGV}=FK and KOK_{TLA}, KOK_{AT}=DK
	10	Non suitable #1EGV
	11	Non suitable #1EGV
	12	Non suitable #1EGV
	13	Non suitable #1EGV
	14	Non suitable EGV
	16	Non suitable EGV
	17	Non suitable EGV
	18	Non suitable #3EGV
	20	Non suitable EGV
MG2040	4	1. $\#3EGV_{ILO} \neq EGV_{TLA}$ 2. $\#4EGV_{ILO} \neq EGV_{TLA}$
	5	Non suitable EGV
	7	Non suitable #1EGV
MG2028	6	Non suitable #1EGV

In order to better understand the Table 7 it is important to point out which can be the causes of misalignment currently identifiable through the knowledge base. The first problem is the use of an EGV that does not reflect any specific action of the learner. Typical case is the use of "understanding". The analysis has revealed many of these cases. This kind of design choice impacts both the %A and the %KA. Second source of misalignment is the use of different verbs for an ILO and related TLA and AT. This lead to lower scores in %A. Third possible cause of low CA is the mismatch between the kind of knowledge in the ILO and in the respective TLA and AT. Last problem is when there are no TLA and/or AT connected with an EGV.

One final remark: the basis for the KPI defined for this work is the EGV. Consequently a different evaluation has been carried on single verbs. The number of data points for each KPI coincides with the number of EGV in a course. This is not the same number of course ILOs since the formulation of the courses may include ILOs introducing more than one single EGV.

6. Discussion

Table 8proposes an expanded view of Table 6 where together with the calculated KPI another two sets of data are presented. One column reports the number of consequent years the courses have been running in a stable form. The second column represents the fraction of teachers with formal CA education on the total number of teachers involved in the course. The sample is very little to infer any conclusion, but the value of KPI seems to be correlated with the "age" of the course and the fraction of teachers with formal CA education.

Table 8 KPI of the courses, years the courses have been active and ratio of teachers with CA education on the total number of teachers involved

Course	%A	%KA	Years	$Teachers_{CAEduc}$/ $Teachers_{total}$
MG1026	87.5%	87.5%	2	1/1
MG2100	81%	86%	1	1/1
MG2033	70%	69%	1	1/5
MG2040	80%	88%	0	1/2
MG2028	91%	100%	8	2/2

The results show both a high degree of alignment, %A, and capability of addressing properly different kind of knowledge, %KA, for all the analyzed courses. This was an expected trend: as mentioned above KTH is a CA conscious institution and, in relation to the specific case study, all the faculties involved with the analyzed courses at IIP have received specific education in CA. Only exception is some of the teachers involved in MG2033: they have no formal education in CA and this explains the lower score emerged from the analysis. This choice is in line with the purpose of this study. Borrowing the term from software industry, the CONALI ontology is still in a "pre-alpha" phase of its development: the case study tested the main intended functions of the ontology. First objective was to verify that if the framework model was expressive enough to capture the information required to address the metrics identified as basic requirement for the evaluation of CA. The results are encouraging: the open world hypothesis that an individual can represent more than one class has helped coping also with unexpected scenarios. One example is teachers that use formative assessment as a TLA to prepare the final exam. The current version of CONALI ontology does not formally support such a course design choice but it was still possible to model it by allocating the same individual (formative assessment) to a TLA and an AT.

Another important feature is the ease of use and understanding of the model. Each course has required between 2 and 4 hours to be instantiated in the knowledge base; the teachers involved have quickly acquired confidence with the model. All the classes and relation have been seamlessly mapped into the related concept of constructive alignment: only minor clarifications were needed.

The CONALI ontology is a promising tool that has been already proved effective in addressing the design and evaluation of higher education following the principle of constructive alignment. This work provides evidence that such an approach is suitable to target the three problematic areas identified in the introduction. In particular with reference to the required effort the proposed framework model allows capturing and representing the essence of CA in a computer understandable way: this is the basic requirement to reduce the effort in implementing and documenting CA initiatives. A precise documentation of CA results is an effective way to win teachers´ resistance to change. Finally the CONALI ontology contributes also in reinforcing the jargon already in use in the domain, and provides a suitable base for enhancing and maintaining such a unified approach.

However this framework is only a first iteration of the envisaged modeling work. There are several functions that must be investigated and resolved. The involvement of more researchers from different fields is required to expand the scope. Some future areas of investigation include:

- Expand the domain of investigation from single EdU to entire programs. This includes also connection between different EdUs.
- Include school in different countries and different discipline to validate the requirements identified in this pilot study and introduce new ones.
- Introduce the connection between assessment task and grading scale. As Biggs point out, having a clear alignment among these two entities is fundamental for the alignment of the course. In view of this different classes must be created for formative and summative assessment in future releases.
- Introduce capability to track EdU across different years with specific metrics to identify and address the "child diseases".
- Integrate the CONALI ontology with valid existing contributions in the domain of CA measurement.

Some of the tools that can exploit the knowledge base are:

- Ad-hoc system to interrogate the knowledge base
- Expert system that can suggest the best way of teaching content based on best practice in the available knowledge base.

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