Ontology for modelling and understanding educational data and concepts – An application to Learning Analytics for Secondary project

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Resumen

El proyecto Learning Analytics for Secondary (LA4S) del inLab FIB se encarga de medir la motivación que los estudiantes tienen sobre sus estudios, a través de trazas digitales. Estas se generan al utilizar las aplicaciones web de soporte al aprendizaje como Moodle o Blackboard, también conocidos como Learning Management Systems (LMS). Un problema que afronta el proyecto LA4S al desarrollar los indicadores sobre la motivación, es la inconsistencia entre los diferentes LMS de los nombres de los conceptos que utilizan en los cálculos de los indicadores. Es decir, entre qué tablas, campos y registros se guardan los datos necesarios.

La ontología que propone éste Trabajo Fin de Grado (TFG) es una estandarización de los conceptos comprendidos dentro del dominio e-learning, y de cómo están relacionados entre ellos. Esta ontología es un resultado genérico y aplicable a cualquier LMS, de tal forma que las herramientas de Learning Analytics desarrollarán los indicadores utilizando los conceptos de la ontología. Esto significa que los datos se extraerán del LMS y serán transformados y guardados siguiendo la nomenclatura estándar de la ontología.

Para validar la ontología, se ha realizado el volcado de los datos de un colegio que utiliza Agora como LMS (una versión de Moodle desarrollada por UPCnet, organización que
The project Learning Analytics for Secondary (LA4S) of inLab FIB is focused on measuring the motivation that students have for their studies, through digital traces. This digital traces are generated while students use web applications for supporting the learning process like Moodle or Blackboard, also known as Learning Management Systems (LMS). One of the problems that the project LA4S deals with, while developing the indicators of motivation, is the inconsistency of the naming of concepts used in the indicators’ definition among the different LMS.

The ontology proposed in this Treball Final de Grau (TFG) is an standarization of the concepts within the e-learning domain, and the relationships between them. This ontology is a generic result and suitable to any LMS, so that the Learning Analytics indicators will be developed using the ontology concepts. This means that the data will be extracted from the LMS and then transformed and loaded following the standard naming of the ontology.

With the purpose of validating the ontology, a data extraction from a school that uses Agora as LMS (a Moodle version developed by UPCnet, organization which collaborates with inLab) participating in the LA4S pilot test has been performed. Then, the concepts had been mapped between the ontology and the LMS using Apache Hive.
Acknowledgements and greetings

This TFG has been a thorough work for over 8 months, and the icing on the cake of my GEI studies and collaboration with inLab FIB. My workmates and my superiors have seen the calm and continuous work, but I want to thank very much my family, Anna B. and Dra. Maria Ribera S. to pat me on the head when things didn’t go as planned.

Albert O. has been a great area responsible on inLab FIB and also a great co-director of this TFG, I felt well supported at all times. Along with Dr. Tomàs A. and Dra. Maria Ribera S., PIs of the Learning Analytics for Secondary project, shared their wide knowledge in e-learning context and allowed me to collaborate with them developing a TFG that has been part of this great Learning Analytics project. Finally, Toni C. has been a great and patient tutor, who attended me at every doubt I had.
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Chapter 1

Introduction

This TFG is a Final Degree Project at FIB-UPC, directed by Maria Ribera Sancho, and Albert Obiols, and supervised by Antonio Cañabate. It has been developed at inLab FIB as part of a Learning Analytics project.

The main goal of this TFG is to develop an ontology, with its concepts and relationships, of the e-learning area. This ontology will help to better represent some aspects of the students behaviour, while they use e-learning platforms.

1.1 Context

We can state two main keywords from the title of the project: Ontologies and Educational Data. So, what is the meaning of these two terms?

An ontology defines different objects from various sciences as etymology, taxonomy or, as in our field of Computer Science, a conceptual schema. So, an ontology provides us with common vocabulary of a given domain, the meaning of the terms used and the relationships between them [1] [2]. They can be classified in several ways, each one with its own purpose [3]:

1. Based on language formality

   - Information ontologies, focused on instances (for example, a mind map).
   - Linguistic or terminological ontologies, focused on semantic relationships (for example, a thesaurus).
   - Software ontologies, focused on data storage (for example, an UML diagram).
• **Formal ontologies**, focused on concepts determined by formal logic (for example, the OWL standard).

2. Based on scope

• **Local or application ontologies**, having a restricted scope for a single viewpoint.

• **Domain ontologies**, applicable to an specific area, with a viewpoint shared by a group of experts on this area.

• **Core reference ontologies**, integrate many domain ontologies linked to an specific domain. Used as an standard.

• **General ontologies**. Are not specialized in a specific area, but they contain many terms of different areas.

• **Foundational ontologies**, they define basic concepts, many of them abstract, like Object, Event, and general classes.

Other authors determine different ways of classification, but the ones explained are enough to understand this project.

**Educational Data** are the traces generated while using a Learning Management System (LMS), which usually is a web application where teachers upload learning materials for supporting the learning process of their students [4]. Currently, Moodle, an open-source LMS, is one of the most used in a huge number of educational organizations.

The term **Learning Analytics** is the name given to the Big Data branch dedicated to the analysis of the Educational Data [5]. One of its main purposes is establishing patterns of student’s behaviour when they perform their activities with a LMS. Then, it can help teachers and pedagogues to better understand the motivation of their students, and prevent them from dropping out of their studies.

Nowadays many Learning Analytics projects are being developed. Particularly this project will focus on the **Learning Analytics for Secondary (LA4S)** project, developed at inLab FIB, in collaboration with Departament d’Ensenyament de la Generalitat de Catalunya.

In addition, **UPCNet** has collaborated with inLab FIB giving feedback and information about Agora, which is a Moodle adapted to the needs of secondary schools in Catalunya. The directors of this TFG are Maria Ribera Sancho, Albert Obiols and Antonio Cañabate, with the additional advice of Tomàs Aluja. They are also the Principal Investigators (PIs) of LA4S. The group participates in the **Spanish Network of Learning Analytics** (SNOLA) and SNOLA is member of the **Society of Learning Analytics Research** (SOLAR).

Also, this project is within the scope of **Plataforma inteligente de learning analytics para mejorar el rendimiento en educación secundaria** (PILARES) project, funded by
Ministerio de Economía y Competitividad (MEC).

This ontology will be used as the conceptual schema on the Learning Analytics for Secondary project, allowing the team to develop their indicators of motivation easily.

1.2 Formulation of the problem

The Learning Analytics field is currently behind several research projects [6] [5] [7] [8], whose results are published in many conferences around the world. For instance, PILARES is one of this research projects that tries to model the students’ behaviour through the usage of the LMS [9].

As a growing field, researchers have been modelling the domain with their own point of view. Concepts are being named without a uniformly rule, leading the field to probable misunderstandings of these concepts.

The Learning Analytics Workgroup (LAW), which is an organization of Stanford University and co-founded by the Bill & Melissa Gates Foundation, coordinated four workshops between 2012 and 2013 which produced a final report [10]. The first section A Conceptual Framework for Building the Field of Learning Analytics laid the foundations for developing a common conceptual framework. Specifically, the second task force was:

Adapting Learning Technologies to Education This task force focused on questions about how to make learning technologies adapt to education. The goal is to evolve the infrastructure for learning analytics for K-12 digital curricula and assessments, e-texts and associated opportunities for big data education science. They focused on the content and method of assessment and data collection. They also considered how to improve the infrastructure according to target users and learning environments.

In July 2013, Agudo-Peregrina et al identified, during their research of predicting success from log data in VLE’s, an absence of a solid theoretical framework, which could help decide the specific data to be analysed [11]. More precisely:

Learning analytics is a rapidly evolving discipline, still undergoing its first stages of development. Although – as mentioned earlier in this paper – there is no consensus to this date on how actual learning analytics might be implemented – e.g. which data is useful, what different considerations have to be made regarding course and individual characteristics, teaching and learning styles, etc. – and empirical results from research may differ largely, we consider that only through a joint effort from the research community to combine theory and practice it will be possible to build a comprehensive learning analytics
framework, which may be useful for all the agents involved in learning processes and educational decision making.

Furthermore, the Learning Analytics Community Exchange (LACE) published in July 2015 a list of policy recommendations for learning analytics, as an outcome of three workshops with stakeholders of the field. Besides other topics like support for institutions and practitioners, the use of Data Standards became an important discussion point. In the chapter that considered the Data Standards issue, the following points were textually included [4]:

**Identify requirements for data collection:** Requirements for data collection, and structures for doing this on a sector or national basis should be identified.

**Introduce and encourage the use of data standards:** It is important to support the development of data standards and to encourage their use, so that there is a standardisation of data to support interoperability.

**Ensure data is associated with metadata using standard conventions:** Policy-makers need to take into account that it is not just the data that analysts are concerned about, because once data is removed from its context it does not necessarily make sense. Data need to be associated with metadata that are produced using standardised conventions.

As seen in previous paragraphs, Learning Analytics field claims for a standard way of modelling and collecting data. This is the main problem being tackled with this TFG. So, the aim of this project is to develop a domain ontology on the Learning Analytics field, and more precisely a conceptual schema written in UML [12] [13] [14]. It will map concepts and data between a Learning Analytics system and a LMS, such as the concepts of Learning Analytics for Secondary project of inLab FIB (taking the data generated with the use of Moodle as reference). This domain ontology pretends to contribute towards improving the current need for the Data Standards issues of organizations like LACE or LAW.

*Figure 1:* Learning Analytics System linked to some example LMS with an ontology.
1.3 State of the art

The use of ontologies in computer science has become increasingly interesting during recent years. As a matter of fact, ontologies have been developed in many domains such as urban planning [15], architecture or civil engineering [3], health and medical domain [16], or even in the baking of pizza domain [17]. An **ontology-based system** provides the ability to access data in a standard way, and also improves the communication between agents (human or software) increasing their interoperability options [3] [18].

As it is stated in the context, Learning Analytics is an area that is experiencing an **increase of interest** in recent years, and some organizations are also investing more funds on it. The concept **Learning Analytics** emerged during the first Learning Analytics and Knowledge Conference of 2011 (LAK’11), and was defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which occurs."[5].

Already around 1950, a series of conferences designed to improve communication between educators was held. The outcome of these conferences was Bloom’s taxonomy [19], which is a set of three hierarchical models used to classify educational learning objectives into levels of complexity and mastery. This three domains are the cognitive (knowledge-based), the affective (emotive-based) and the psychomotor (action-based).

IMS Global Learning Consortium (IMS) began to develop their Learning Resource Meta-data specification (LRM), which is a data model used to describe a learning object and similar digital resources used to support learning. In July 2002, with the release of the version 1.3, this specification became the actual IEEE 1484.12.1:2002 standard, known as Learning Object Metadata (LOM). It was developed by IMS along with ARIADNE foundation.

There have been different attempts to merge the domains of ontologies and learning Analytics, as for example in the research of Cambruzzi et al [6]. Some authors have tried to model e-learning environments [20] [21] and some other have gone far in a conceptualization of this learning context [22], or have also developed frameworks to evaluate ontologies for web-based learning [2].

As Tankelevičienė and Damaševičius stated [20] in his Learning Context Model (LCM), its purpose is to represent variability of learning context focused on e-learning process. They stipulate as future work to extend their LCM specifying it as a domain ontology. This research has been cited by other authors in their research. For example, in the development of a framework for on-line learning and MOOCs [23], or in an ontology to describe personalized learning contexts [24].

In June 2009, the **Ministerio de Educación** along with the **Ministerio de Industria, Turismo y Comercio**, adapted LOM standard to Spanish education needs through the standarization entity AENOR in collaboration with Red.es [9]. As a result, **LOM-ES V1.0** was developed.
They were not the only ones: other countries had the same initiatives, as Canada with CanCore, UK with UK LOM Core or France with LOM-FR.

In June 2010, IMS released the final specifications for the Learning Tools Interoperability (LTI) Standard, but its implementation started in 2008 as a project developed by Jordi Piguillem, Marc Alier and Charles Severance. LTI allows to connect learning systems such as Learning Management Systems with external service tools and it also provides a vocabulary of Learning Context and User Roles [25]. The newest version is LTI v1.2, released in January 2015, and provides a vocabulary of the Learning Context and User Roles.

At 2012 the Common Core State Standards Initiative provide clear and consistent learning goals. This standards define what students are expected to learn at each grade level. They differentiate between English Language Arts/Literacy Standards[26] and Mathematics [27] Standards.

The Tin Can API provides a framework that collects data about the experience a person has. It is intended to be applied in a Learning Management System so as to record the actions a user performs within the LMS. These actions have the syntax Subject + Verb + Object and it also has a public registry with the vocabulary to use.

In 2013 the Predictive Analytics Reporting (PAR) Framework came on the scene, funded by the Bill & Melinda Gates foundation. With the purpose of identifying common factors contributing to student loss, and finding effective practices to improve students progression[28], this study created a dataset to explore and analyze these factors. Six organizations worked together to define the 33 variables of the dataset.

IMS published in September 2013 a whitepaper introducing Caliper Analytics. In this publication they also identified the absence of a standard set of metrics to measure the learning activity [29], and referenced the previous cited Bloom’s taxonomy, the Common Core State Standards Initiative and the PAR Framework. Caliper is the most similar project to LA4S project of inLab FIB. It consists in a framework which gets the learning metrics by implementing a sensor in the Virtual Learning Environment. This sensor catches the learning events generated by the student expressed in the form of a data triple based on RDF Triple form (subject, predicate, object). Although it is an ontology, it does not represent the educational context, but a subset of the learning analytics context.

In September 2015, IMS also released the specifications of Question & Test Interoperability Specification (QTI) v2.2. This is a tool that enables the exchange of item and test content and results data between authoring tools, item banks, test construction tools, learning platforms, assessment delivery systems, and scoring/analytics engines. Besides the tool, its

1. They were not the only ones: other countries had the same initiatives, as Canada with CanCore, UK with UK LOM Core or France with LOM-FR.

1 http://educalab.es/recursos/lom-es
2 http://www.corestandards.org
3 http://tincanapi.com/overview/
4 http://www.imsglobal.org/activity/caliperram
5 https://www.imsglobal.org/question/index.html
specification provides a vocabulary about Question and Assessment.

On the other hand, and as stated in their own description, schema.org is a collaborative, community activity with a mission to create, maintain, and promote schemas for structured data on the Internet. Schema.org defines two different hierarchies: one is for data types, and the other one is for vocabulary. Its vocabulary has as the most general class Thing which is defined as the most generic type of item, and then, subclasses of Thing are defined like Event, Person or Intangible.

The following table tries to summarize all the research above and what can be used of every one:

Table 1: Summary of existing frameworks or studies.

<table>
<thead>
<tr>
<th>Name</th>
<th>Potential use</th>
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</tr>
<tr>
<td>IMS LOM</td>
<td>Learning Object definition.</td>
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<tr>
<td>educaLab LOM-ES</td>
<td>Cognitive process.</td>
</tr>
<tr>
<td>IMS LTI</td>
<td>Learning Context and User Roles.</td>
</tr>
<tr>
<td>Common Core SS</td>
<td>Learning goals and objectives.</td>
</tr>
<tr>
<td>Tin Can API</td>
<td>The registry of statements.</td>
</tr>
<tr>
<td>IMS Caliper</td>
<td>Actions and session metrics.</td>
</tr>
<tr>
<td>IMS QTI</td>
<td>Question, Assessment and Interactions.</td>
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Specifically, LA4S project of inLab FIB is now in development. It has a platform to **extract** the data from Agora, a platform to **process** this data, a system of indicators based on the processed data, and a web-based application for the **visualization** of these indicators.

One of the main problems in LA4S project is the lack of a conceptual schema, that defines exactly from which tables the indicators are being retrieved. This is an issue for the developing team when defining the indicators, such as when students have accessed a learning material, or when they have submitted their work. This TFG pretends to tackle this main problem proposing an ontology as a conceptual schema.

According to these previous works, and having read the policy recommendations for learning analytics stated by Learning Analytics Community Exchange (LACE) in July 2015, along with the Learning Analytics Workgroup (LAW) Framework, **there is not a standard ontology for this domain** [4]. For this reason, an **ontology for understanding the educational data**

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6http://www.schema.org
and concepts will be developed extending and integrating previous studies pointed out in this section.

1.4 Scope of the project

This TFG is scoped into the Learning Analytics for Secondary project of inLab FIB. The ontology must represent the concepts of the Educational Context, focused on the formal education\textsuperscript{7} and blended learning\textsuperscript{8}, from Elementary School to High School. It will, for example, contain all the concepts in Agora, which is a personalized Moodle developed by UPCNet and provided by Generalitat de Catalunya to more than 1300 schools in Catalunya.

Particularly, in LA4S some concepts are defined without a schema. These have been defined by a first exploratory data analysis on a subset of tables taken from the Agora database, and a few indicators have derived from these concepts. The project is facing an update of Agora, so the ontology will define the concepts used on the new 2.8 version (that has a new logging system) among other concepts without representation in this LMS.

Not having an ontology of Learning Analytics domain is an obstacle for this project development, because it would help to get a first general idea of some concepts in this domain. Also, not having a pedagogue in our team is forcing us to adapt our knowledge in this area to the data generated by the use of students with Moodle. This TFG could avoid these issues by reading and studying the results published by authors in their academic articles.

1.4.1 Project goals description

To develop an ontology for the Educational Context domain, suitable for Learning Analytics.

In the software field, an ontology is understood in different ways. Therefore, in this TFG will be accepted as an enriched conceptual schema. In order to complete this goal, first the representative concepts of the Learning Analytics domain must be set by studying the results from experts articles. Every concept will have its semantic definition, and a set of properties and attributes. Finally, the relationships with their cardinalities will be stated between these terms. As a result, this will be the conceptual schema that will define the ontology of Educational Context domain.

To map the concepts of the Learning Analytics ontology with Moodle Database

\textsuperscript{7}Systematic, organized education model, structured and administered according to a given set of laws and norms.

\textsuperscript{8}Formal education program in which a student learns at least in part through delivery of content and instruction via digital and online media.
As the Ontology will represent the concepts on Educational Context and Learning Analytics domain, this will be validated through an implementation with a LMS. All the concepts in this LMS must comprise a subset of the concepts of the Ontology. Consequently, the implementation will map all the concepts of the LMS to the appropriate concept of the ontology, being this ontology represented as a database.

1.4.2 Possible risks and deviations

In the example implementation between a LMS and this ontology, the maximum amount of real-use data from the students is needed. So, if data from the use of Agora by Catalan students was not received, it would be an important obstacle. This could happen for many reasons, for example if schools didn’t want to collaborate with the project, or if the Departament d’Ensenyament or MEC stopped providing the data.

Research projects also are more difficult to plan, as the ending point is not as clear as a development project. Because the nature of this type of project contains a component of uncertainty, some deviations may arise.

1.5 Methodology and procedure

As Roussey states [3], there are different ontology design approaches. Focusing on this project, it is desired to apply the **middle out approach**, by first identifying the central concepts and then developing the schema by identifying the concepts that are related around them [30].

The central concepts will be identified by two sources. On the one hand, **exploring the Agora database** and understanding its structure. Tables represent concepts in e-learning context, moreover the relations between themselves and with the logging table will represent concepts in the Learning Analytics domain. On the other hand, existing works in the field of Learning Analytics will be studied and, depending on their applicability, their concepts will be taken into account. All these Learning Analytics concepts will be the central concepts with which the ontology will be developed.

As explained in previous chapters, this project is scoped in the LA4S project of inLab FIB. LA4S is using **scrum** methodology for its development, and PILARES is also using agile methodology to coordinate the project teams. So, with the purpose of coordinating the work with LA4S, scrum methodology will be used.

To supervise the evolution of this project, **weekly meetings** are being held every Tuesday
at 9:30 AM with the co-directors of this TFG, the directors of LA4S project and its team members. The purpose of these meetings is to manage the project in short cycles to avoid misunderstandings and being on the right track.

To evaluate the quality of the domain ontology it has been proposed to use the framework of Tankelevičienė [2], a well-known researcher in this field, which will validate its correctness. Also, with the update to the new version of Agora (2.8) the ontology must represent the concepts used in this version, so this will validate its completeness.
Chapter 2

Project Management

2.1 Initial project planning

This was the initial planning, prepared during GEP\textsuperscript{1} before the development stage. Thanks to the agile methodology, there have been some justified deviations in this initial planning. As there have been many changes, the next section \textbf{Final project planning} collects all these modifications and proposes a more accurate planning.

2.1.1 Initial Schedule

The estimated duration of the project is 5 months, starting on September, 2015 and ending on January, 2016. Local holidays and Christmas are contemplated. Using agile methodology implies there can be some deviations, so this schedule is an approximation. This means it can be revised and updated during the development of the project.

2.1.2 Initial Planning

The following tasks must be completed to finish the project. All the tasks follow linear dependency, so they are going to be completed in the following order.

\textsuperscript{1}“Gestió de Projectes” subject of the degree.
Project planning and management

This phase includes the development of all the artifacts suggested by GEP course, including the following phases:

1. **Project scope and context:**
   The aim is to write about the contextualization of the knowledge area which the project belongs to. First of all, lots of academic articles will have to be read. However, many of them will not be relevant, so this is also a phase to filter good sources of information. Secondly, and having comprehended all the relevant information, an initial state of the art must be described with its context. Finally, the scope of the project, objectives and methodology used to develop it will be stated.


   Length: 30 hours.

2. **Project planning.**
   The purpose of this stage is to define the tasks which must be performed to achieve the goal of the project. It also states the resources and feasibility.

   Resources: 1 Personal Computer. TeXstudio.

   Length: 10 hours.

3. **Project budget.**
   In order to estimate the cost of resources used, this document must reflect what human and economic resources will have to be used. The sustainability will be evaluated along with the economic feasibility.

   Resources: 1 Personal Computer. TeXstudio.

   Length: 12 hours.

Project development

At this point, the planning and action plan have been stated, and the feasibility of the project in economical and timing terms have been validated before. So, this next phase is divided into the following stages:

1. **Set-up the environment.**
   To properly develop the ontology, some frameworks and software must be installed and configured.
Resources: 1 Personal Computer. Instance of Moodle. XAMPP. Zotero. Pentaho DI.

Length: 20 hours.

2. **Acquire knowledge about ontologies and Learning Analytics.**
   There is a lot of documentation about these two areas. Therefore in this stage it is necessary to gain some knowledge about ontologies and Learning Analytics.


   Length: 80 hours.

3. **Exploratory Database Analysis of Moodle.**
   To better understand which data is stored from the use of platform by students, we will get data from the Agora (Moodle) platform and perform an exploratory database analysis.

   Resources: 1 Personal Computer. Instance of Moodle. XAMPP.

   Length: 80 hours.

4. **Examine Learning Analytics for Secondary (LA4S) Database.**
   Due to the fact that LA4S project developed a pilot ETL process, which performed some analytics on Agora use of pilot subjects, this database will be a good start point to understand some concepts in the area of Learning Analytics.

   Resources: 1 Personal Computer. XAMPP.

   Length: 50 hours.

5. **Link concepts between LA4S and Moodle.**
   Once determined which concepts are representative for this knowledge domain, they have to be linked to Moodle database. So, a conceptual schema will be developed at this stage.

   Resources: 1 Personal Computer. Instance of Moodle. XAMPP. Pentaho DI.

   Length: 100 hours.

6. **Develop the ontology**: ²
   Along with the previous conceptual schema of Learning Analytics, the ontology will be developed.

   Resources: 1 Personal Computer. XAMPP. Pentaho DI.

²As will be seen in next section, the order will be different.
Length: 100 hours.

Resources for the whole phase: 1 Personal Computer, Moodle local or in a server instances, Data from Moodle use, academic articles database access.

Project validation and final stage

Once the ontology has been developed, it must be validated with the appropriate framework. Then, the final report will be written and delivered. Furthermore a final presentation will be performed to defend the TFG before a court.


Length: 60 hours.

2.1.3 Initial Estimated Time

Table 2: Estimated time

<table>
<thead>
<tr>
<th>Phase</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Planning and Management</td>
<td>52</td>
</tr>
<tr>
<td>Project Development</td>
<td>430</td>
</tr>
<tr>
<td>Validation and Final stage</td>
<td>60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>542</strong></td>
</tr>
</tbody>
</table>
2.1.4 Initial Gantt Chart

<table>
<thead>
<tr>
<th>Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Planning and Management</td>
<td>11d?</td>
<td>01/09/2015</td>
<td>15/09/2015</td>
</tr>
<tr>
<td>Project Scope and Context</td>
<td>5d?</td>
<td>01/09/2015</td>
<td>07/09/2015</td>
</tr>
<tr>
<td>Project Planning</td>
<td>2d?</td>
<td>08/09/2015</td>
<td>09/09/2015</td>
</tr>
<tr>
<td>Project Budget</td>
<td>4d?</td>
<td>10/09/2015</td>
<td>15/09/2015</td>
</tr>
<tr>
<td>Project Development</td>
<td>8d?</td>
<td>14/09/2015</td>
<td>10/12/2015</td>
</tr>
<tr>
<td>Setup the environment</td>
<td>2d?</td>
<td>16/09/2015</td>
<td>17/09/2015</td>
</tr>
<tr>
<td>Acquire knowledge about ontologies and Learning Analytics</td>
<td>11d?</td>
<td>21/09/2015</td>
<td>05/10/2015</td>
</tr>
<tr>
<td>Exploratory Database Analysis of Moodle</td>
<td>11d?</td>
<td>06/10/2015</td>
<td>20/10/2015</td>
</tr>
<tr>
<td>Examine Learning Analytics for Secondary (LA4S) Database</td>
<td>7d?</td>
<td>21/10/2015</td>
<td>29/10/2015</td>
</tr>
<tr>
<td>Link concepts between LA4S and Moodle</td>
<td>14d?</td>
<td>30/10/2015</td>
<td>18/11/2015</td>
</tr>
<tr>
<td>Develop the ontology</td>
<td>16d?</td>
<td>19/11/2015</td>
<td>10/12/2015</td>
</tr>
<tr>
<td>Project Validation and Final Stage</td>
<td>8d?</td>
<td>11/12/2015</td>
<td>22/12/2015</td>
</tr>
<tr>
<td>Report writing</td>
<td>8d?</td>
<td>11/12/2015</td>
<td>22/12/2015</td>
</tr>
</tbody>
</table>

Figure 2: Gantt chart with all the tasks and activities to perform.
2.1.5 Alternatives

In accordance with the previous delivered document, it is important to remember that this TFG is in the scope of Learning Analytics For Secondary project, being already developed in inLab FIB. Due to the use of agile methodologies, there may be some deviations.

One of the possible issues we may deal with, is the lack of real-use data from students of Catalunya. In this case, there are Moodle courses with real-use data but they are not from Catalan students. This solution might add approximately 30 hours of work.

2.1.6 Action Plan

Having the planning proposed as a guideline, there will be activities that will last more time than the expected, whereas some others will last less. It will be fixed by holding weekly meetings on Tuesdays, and revising on the planning.

The weekly workload to develop this TFG is 28 hours.

Resources

As stated in the previous chapter, the following resources will be used in the whole project, along with others less important:

- 1 Personal Computer with Windows.
- Access to academic articles databases from UPC.
- Moodle 2.6 and 2.8 with access to its database.
- XAMPP.
- TeXstudio.

Feasibility

As seen in this document, this TFG is attainable within the time proposed in the schedule.
2.2 Final project planning

2.2.1 Schedule

The duration of the project has been 7 months, starting on September, 2015 and ending on April, 2016. The workload is 25 weekly hours: **5 hours every day**. Local holidays and Christmas have been contemplated. In comparison with the initial planning, there has been a deviation of 2 months, due to several reasons detailed in the *Deviations* section.

2.2.2 Planning

The following tasks have set the path to finish the project. All the tasks followed linear dependency, so they were completed in the following order.

**Project planning and management**

This phase includes the development of all the artifacts suggested by GEP course, including the following phases:

1. **Project scope and context:**
   The aim is to write about the contextualization of the knowledge area which the project belongs to. First of all, lots of academic articles will have to be read. However, many of them will not be relevant, so this is also a phase to filter good sources of information. Secondly, and having comprehended all the relevant information, an initial state of the art must be described with its context. Finally, the scope of the project, objectives and methodology used to develop it will be stated.


   Length: 25 hours.

2. **Project planning.**
   The purpose of this stage is to define the tasks which must be performed to achieve the goal of the project. It also states the resources and feasibility.

   Resources: 1 Personal Computer. TeXstudio.

   Length: 10 hours.

3. **Project budget.**
In order to estimate the cost of resources used, this document must reflect what human and economic resources will have to be used. The sustainability will be evaluated along with the economic feasibility.

Resources: 1 Personal Computer. TeXstudio.

Length: 20 hours.

**Project development**

At this point, the planning and action plan have been stated, and the feasibility of the project in economical and timing terms have been validated before. So, this next phase is divided into the following stages:

1. **Set-up the environment.**
   To properly develop the ontology, some frameworks and software must be installed and configured.


   Length: 20 hours.

2. **Acquire knowledge about ontologies and Learning Analytics.**
   There is a lot of documentation about these two areas. Therefore in this stage it is necessary to gain some knowledge about ontologies and Learning Analytics.


   Length: 100 hours.

3. **Develop data processing scripts**
   It’s necessary to develop two scripts for processing the data we get from Departament d’Educació. So, the first script will automate the download of the files from the Agora portal of Departament d’Educació, and the second script will manage the loading of this data into our local database.


   Length: 30 hours.

4. **Exploratory Data Analysis of Moodle.**
   To better understand which data is stored from the use of platform by students, we
will get data from the Agora (Moodle) platform and perform an exploratory database analysis.

Resources: 1 Personal Computer. Instance of Moodle. XAMPP. Database Browser.

Length: 55 hours.

5. **Examine Learning Analytics for Secondary (LA4S) Database.**

Due to the fact that LA4S project developed a pilot ETL process, which performed some analytics on Agora use of pilot subjects, this database will be a good start point to understand some concepts in the area of Learning Analytics.


Length: 35 hours.

6. **Research about existent ontologies in learning context.** Some ontologies of the learning context have been developed, or are in inception phase. The goal of this phase is to do a research and analysis of these vocabularies or ontologies and, if necessary, merge them.


Length: 70 hours.

7. **Develop the ontology.**

In this phase, the conceptual schema will be developed with the appropriate tool.


Length: 80 hours.

8. **Implement the ontology with Agora database.**

Once the ontology has been developed, the concepts represented on the conceptual schema will be mapped to the Moodle Agora database. It will also validate the completeness.


Length: 70 hours.
Project validation and final stage

Once the ontology has been developed, it must be validated with the appropriate framework. Then, the final report will be written and delivered. Furthermore a final presentation will be performed to defend the TFG before a jury.

1. **Validation**
   Using the appropriate framework, the correctness of the ontology will be validated.


   Length: 50 hours.

2. **Report writing**
   The results of the TFG must be written in this final report.


   Length: 125 hours.

3. **Composing of defense presentation.** The results of the TFG must be defended before a court. For this reason, a presentation with slides will be composed.

   Resources: 1 Personal Computer. Google Drive.

   Length: 30 hours.

### 2.2.3 Time

*Table 3: Estimated time*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Planning and Management</td>
<td>55</td>
</tr>
<tr>
<td>Project Development</td>
<td>460</td>
</tr>
<tr>
<td>Validation and Final stage</td>
<td>205</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>720</td>
</tr>
</tbody>
</table>
### 2.2.4 Gantt Chart

<table>
<thead>
<tr>
<th>Nombre</th>
<th>Duración</th>
<th>Ini</th>
<th>Fin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Planning and Management</td>
<td>11d?</td>
<td>01/09/2015</td>
<td>15/09/2015</td>
</tr>
<tr>
<td>Project Scope and Context</td>
<td>5d?</td>
<td>01/10/2015</td>
<td>07/10/2015</td>
</tr>
<tr>
<td>Project Planning</td>
<td>20d?</td>
<td>05/09/2015</td>
<td>20/09/2015</td>
</tr>
<tr>
<td>Project Budget</td>
<td>4d?</td>
<td>10/09/2015</td>
<td>15/09/2015</td>
</tr>
<tr>
<td>Project Development</td>
<td>10d?</td>
<td>16/09/2015</td>
<td>28/01/2016</td>
</tr>
<tr>
<td>Set-up the environment</td>
<td>4d?</td>
<td>16/09/2015</td>
<td>21/09/2015</td>
</tr>
<tr>
<td>Acquire knowledge about ontologies and Learning Analytics</td>
<td>20d?</td>
<td>22/09/2015</td>
<td>28/11/2015</td>
</tr>
<tr>
<td>Develop data processing scripts</td>
<td>6d?</td>
<td>22/10/2015</td>
<td>27/11/2015</td>
</tr>
<tr>
<td>Research about existing ontologies in learning context</td>
<td>14d?</td>
<td>23/11/2015</td>
<td>10/12/2015</td>
</tr>
<tr>
<td>Develop the ontology</td>
<td>15d?</td>
<td>11/12/2015</td>
<td>26/01/2016</td>
</tr>
<tr>
<td>Implement ontology with Apea Database</td>
<td>14d?</td>
<td>11/01/2016</td>
<td>28/01/2016</td>
</tr>
<tr>
<td>Project Validation and Final Stage</td>
<td>11d?</td>
<td>20/01/2016</td>
<td>25/01/2016</td>
</tr>
<tr>
<td>Validate</td>
<td>10d?</td>
<td>20/01/2016</td>
<td>11/02/2016</td>
</tr>
<tr>
<td>Report writing</td>
<td>2d?</td>
<td>12/02/2016</td>
<td>17/03/2016</td>
</tr>
<tr>
<td>Composing of Defense presentation</td>
<td>6d?</td>
<td>18/03/2016</td>
<td>25/03/2016</td>
</tr>
</tbody>
</table>

*Figure 3: Gantt chart with all the tasks and activities to perform.*
2.3 Differences between initial and final project planning

As prescribed in the scope, according to the nature of a research project, there have been a few changes in the initial project planning. The main difference can be noted in the deviation of the estimated time, which was initially estimated in 542 hours and finally have been 720 hours. It is indeed a large increase of hours, but also legitimate as can be read in the project obstacles section.

Over and above the increase of the Validation and Final Stage, which belongs mainly to the final report writing, the most notable increase is in the Project Development Stage. The development stage was initially divided into 6 tasks, but the appearance of new studies during the development of this TFG made more difficult the research, having to increase the number of stages. This is properly explained in the project obstacles section. Anyway, some tasks had to be reordered and renamed due to the initial inexperience in the field, during the first month of the project.

In conclusion, all the changes had impact on the human resources cost: firstly the software developer had to work 490 hours at 7.5€/h (3.675,00 €), but all the obstacles increased the workload to 665 hours (making a total of 4.970,50 €). On the other hand, new tools used did not increase the budget because they are all free-licensed.

2.4 Project budget

As seen in previous delivered documents, in order to complete this TFG some resources must be used. They are divided into four groups: human, hardware, software and other resources.

To properly link the resources and tasks defined in the activity plan, they will be coded as follows:
Table 4: Activity coding

<table>
<thead>
<tr>
<th>Code</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project planning and management</strong></td>
<td>P</td>
</tr>
<tr>
<td>Project scope and context</td>
<td>P1</td>
</tr>
<tr>
<td>Project planning</td>
<td>P2</td>
</tr>
<tr>
<td>Project budget</td>
<td>P3</td>
</tr>
<tr>
<td><strong>Project development</strong></td>
<td>D</td>
</tr>
<tr>
<td>Set-up the environment</td>
<td>D1</td>
</tr>
<tr>
<td>Acquire knowledge about ontologies and Learning Analytics</td>
<td>D2</td>
</tr>
<tr>
<td>Develop data processing scripts</td>
<td>D3</td>
</tr>
<tr>
<td>Exploratory Database Analysis of Moodle</td>
<td>D4</td>
</tr>
<tr>
<td>Examine Learning Analytics for Secondary (LA4S) Database</td>
<td>D5</td>
</tr>
<tr>
<td>Research about existent ontologies in learning context</td>
<td>D6</td>
</tr>
<tr>
<td>Develop the ontology</td>
<td>D7</td>
</tr>
<tr>
<td>Implement the ontology with Agora database</td>
<td>D8</td>
</tr>
<tr>
<td><strong>Project validation and final stage</strong></td>
<td>F</td>
</tr>
<tr>
<td>Validation</td>
<td>F1</td>
</tr>
<tr>
<td>Report writing</td>
<td>F2</td>
</tr>
<tr>
<td>Composing of defense presentation</td>
<td>F3</td>
</tr>
</tbody>
</table>

2.4.1 Human Resources

As the project is going to be developed by only one person, this person must take the role of Project Manager and Software Developer.

Table 5: Human resources budget

<table>
<thead>
<tr>
<th>Concept</th>
<th>Activity</th>
<th>Hours</th>
<th>Price/Hour</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>P</td>
<td>55 h</td>
<td>51 €/h</td>
<td>2.805,00 €</td>
</tr>
<tr>
<td>Software Developer</td>
<td>D,F</td>
<td>665 h</td>
<td>7.5 €/h</td>
<td>4.987,50 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>7.792,50 €</td>
</tr>
</tbody>
</table>
2.4.2 Hardware Resources

During the development of this TFG some hardware will be used. In Table 3 there is a list of what hardware is going to be necessary, with its amortization taking into account their useful life.

*Table 6: Hardware budget*

<table>
<thead>
<tr>
<th>Concept</th>
<th>Activity</th>
<th>Price</th>
<th>Useful life</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Computer intel Core i5</td>
<td>P,D,F</td>
<td>830,00 €</td>
<td>4 years</td>
<td>138,33 €</td>
</tr>
<tr>
<td>Server AMD Quad Core Opteron</td>
<td>D</td>
<td>2,700,00 €</td>
<td>4 years</td>
<td>450,00 €</td>
</tr>
<tr>
<td>Asus X200CA Netbook</td>
<td>P,F</td>
<td>420,00 €</td>
<td>4 years</td>
<td>70,00 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>658,33 €</strong></td>
</tr>
</tbody>
</table>

2.4.3 Software Resources

Most of the software products that are going to be used are open-source, instead of others that have a license cost.
### Table 7: Software budget

<table>
<thead>
<tr>
<th>Concept</th>
<th>Activity</th>
<th>Price</th>
<th>Useful life</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moodle 2.6</td>
<td>D1,D4</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>TeXstudio 2.10</td>
<td>P,F</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>XAMPP 5.6.12</td>
<td>D1,D3,D4,D5,D7</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Database Browser 3.0</td>
<td>D3,D4,D5</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Google Drive</td>
<td>P,D,F</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Zotero 4.0</td>
<td>P,D1,D2,D6,F</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Pentaho Data Integration 5.4</td>
<td>D1,D5,D6</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Cloudera</td>
<td>D1,D3,D8</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>eclipse MARS + Papyrus</td>
<td>D7</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Modelio</td>
<td>D7</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Bitbucket account</td>
<td>P,F2</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Sublime Text 3</td>
<td>D3,D8</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Linux Ubuntu 14.04</td>
<td>D</td>
<td>N/A</td>
<td>N/A</td>
<td>0,00 €</td>
</tr>
<tr>
<td>Windows 8 Professional</td>
<td>P,D,F</td>
<td>69,99 €</td>
<td>3 years</td>
<td>19,44 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>19,44 €</td>
</tr>
</tbody>
</table>

#### 2.4.4 Other Resources

Some other licenses will have to be bought to develop this project. Also, there are some indirect costs to be assumed. These are detailed in the following Table 5:

#### 2.4.5 Resources monitoring

As the project uses agile methodology for its development, possible deviations can be detected and corrected faster. At every meeting the progress of the project will be updated, as well as the possible obstacles that will appear.

So as to monitor human resources, the TFG development must follow the previously defined Gantt chart. This can help to find deviations in human resources dedication.
### Table 8: Other budget

<table>
<thead>
<tr>
<th>Concept</th>
<th>Activity</th>
<th>Price</th>
<th>Useful life</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to Papers DB</td>
<td>P,D2,D6,F</td>
<td>N/A</td>
<td>N/A</td>
<td>No additional cost inside UPC Network</td>
</tr>
<tr>
<td>Energy</td>
<td>P,D,F</td>
<td>300,00 €/y</td>
<td>N/A</td>
<td>125,00 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>125,00 €</strong></td>
</tr>
</tbody>
</table>

#### 2.4.6 Total cost

In order to estimate the total cost of this project, all the previous budgets must be added up, as shown in Table 6:

### Table 9: Total budget

<table>
<thead>
<tr>
<th>Concept</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Resources</td>
<td>7.792,50 €</td>
</tr>
<tr>
<td>Hardware Resources</td>
<td>658,33 €</td>
</tr>
<tr>
<td>Software Resources</td>
<td>19,44 €</td>
</tr>
<tr>
<td>Other Resources</td>
<td>125,00 €</td>
</tr>
<tr>
<td>Possible Deviations (30h)</td>
<td>1.530,00 €</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10.125,27 €</strong></td>
</tr>
</tbody>
</table>

#### 2.5 Sustainability

##### 2.5.1 Economic

Taking into account the previous chapter, all human and material resources are estimated. It’s relevant to notice the use of mostly open-source software. In addition, the licenses that UPC has with many academic articles databases eases the access to knowledge. So, it is feasible and competitive in economic terms.

The duration of each activity is estimated and fitted in relation of its importance. As stated in
the context of the project there is not a similar functional solution, so no existing technology can be reused. Because this TFG is part of Learning Analytics for Secondary project, already being developed at inLab FIB, the deadline is estimated by them.

Also, this TFG may have impact in the economy of organizations: they may save costs in research if they re-use this solution.

Finally, there has been a deviation of a 36% more hours dedicated to develop the project. It also has been translated into an increase of the cost. This deviation has been caused by the appearances of new studies of the field, so on the positive side it showed a good adaptation to the changes.

2.5.2 Social

This project will be developed in the sector of Computer Science in Catalonia, focused on an educational scope. It will be a tool for data analysts and software engineers, which will enable them to develop solutions of learning analytics.

As LACE specifies in their Policy Recommendations For Learning Analytics From Three Stakeholder Workshops, the sector agreed that there is a need of identifying data standards. This means that the development of an ontology will surely improve the sector of learning analytics. Better solutions of learning analytics will help teachers to detect learning patterns of their students. So, this results in better teaching by teachers and more motivation by students.

The direct impact of this TFG will be delimited to the Educational domain, but is expected a long-term indirect impact resulting in more motivated students. Besides this, the development of this project is not going to harm directly or indirectly any collective.

2.5.3 Environmental

Considering in a Computer Science project there will be emissions of CO2 for sure, our main objective is reduce them to the minimum. So, we will assume that a desktop computer consumes 250 watts, and a netbook consumes 140 watts. The desktop will be used along the 80% of the time, instead of the 20% of the netbook. Taking these values into account, the energy consumed will be 123KW, so the ecological footprint will be of 47.355 kg of CO2. All the academic articles that have to be read, will not be printed but read from a computer screen.

All the results of this TFG will be open-source and available to the learning analytics community for any further enhancements or studies.
### 2.5.4 Matrix of sustainability

The following table evaluates sustainability from the three areas assessed:

*Table 10: Matrix of sustainability*

<table>
<thead>
<tr>
<th>Sustainable?</th>
<th>Economic</th>
<th>Social</th>
<th>Environmental</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planning</strong></td>
<td>Economic viability</td>
<td>Improved quality of life</td>
<td>Resource analysis</td>
<td>27</td>
</tr>
<tr>
<td>Assessment</td>
<td>10 (0:10)</td>
<td>10 (0:10)</td>
<td>7 (0:10)</td>
<td>(0:30)</td>
</tr>
<tr>
<td><strong>Results</strong></td>
<td>Final cost vs prevision</td>
<td>Social Impact</td>
<td>Resource Consumption</td>
<td>14</td>
</tr>
<tr>
<td>Assessment</td>
<td>4 (-10:10)</td>
<td>7(-10:10)</td>
<td>3 (-10:10)</td>
<td>(-30:30)</td>
</tr>
<tr>
<td><strong>Risks</strong></td>
<td>Scenario changing adaptation</td>
<td>Social harm</td>
<td>Environmental harm</td>
<td>-10</td>
</tr>
<tr>
<td>Assessment</td>
<td>0 (-20:0)</td>
<td>0 (-20:0)</td>
<td>-10 (-20:0)</td>
<td>(-60:0)</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>17</td>
<td>0</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>(-30:20)</td>
<td>(-30:20)</td>
<td>(-30:20)</td>
<td>(-90:60)</td>
</tr>
</tbody>
</table>
Chapter 3

Project Development

3.1 Alternatives analysis

Due to the nature of the project, a set of solutions for different purposes are going to be evaluated. This TFG requires tools for organizing academic articles, for developing the conceptual schema in the chosen language and also tools for mapping the raw data as the classes of the ontology suggest.

3.1.1 Alternatives description

Academic papers

There are many solutions for storing a database of academic articles. As this TFG requires to properly store and classify an important number of papers, these solutions have been considered:
<table>
<thead>
<tr>
<th>Name</th>
<th>Main features</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zotero</td>
<td>Desktop and web application which stores the references.</td>
<td>• Chrome plugin.</td>
<td>• Does not provide a GUI for searching publications.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• LaTeX BibTex exporting.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stores the document locally.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fetches automatically the metadata of the publication.</td>
<td></td>
</tr>
<tr>
<td>EndNote</td>
<td>Web application with a bibliographic database and linked to available journals.</td>
<td>• Integration with WebOfScience.</td>
<td>• Access depends on institutions’ subscriptions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Easy citation system.</td>
<td></td>
</tr>
<tr>
<td>Readcube</td>
<td>Desktop and browser-based for managing, annotating and managing academic</td>
<td>• Integrated with search systems.</td>
<td>• Does not have LaTeX-format exporting.</td>
</tr>
<tr>
<td></td>
<td>research articles.</td>
<td>• Stores the document locally.</td>
<td></td>
</tr>
</tbody>
</table>

**Ontology language development**

Ontologies can be developed in different languages. This section introduces these languages and their main aspects.
### Table 12: Ontology development language options

<table>
<thead>
<tr>
<th>Name</th>
<th>Main features</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDF</td>
<td>Standard model for data interchange on the web based on triples.</td>
<td>• It is a standard.</td>
<td></td>
</tr>
<tr>
<td>OWL</td>
<td>Knowledge representation language for authoring ontologies.</td>
<td></td>
<td>• Does not support Association classes.</td>
</tr>
</tbody>
</table>
| UML  | General-purpose, developmental and modeling language in the field of software engineering. | • Focused on software engineering.  
• Widely used.  
• A lot of software options available. | |
<table>
<thead>
<tr>
<th>Name</th>
<th>Main features</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| ArgoUML    | Last release 0.34 (2011)       | • Has an automatic Reasoning Tool developed by FIB.  
• Free license. | • Supports up to UML 1.4.  
• Non-participative community. |
| BOUML      | Last release Oct 2015.         | • Supports UML 2.  
• Good community. | • License costs 30€ |
| StarUML    |                                 | • Supports UML 2.  
• Widely used by big companies.  
• Good community. | • License costs 49$ |
| UML Designer | Plugin for eclipse.       | • Supports UML 2.5.  
• Good tutorials.  
• Free license.  
• Good community. | • Supports up to UML 1.4. |
| Protégé    | Ontology editor and model validator developed by Stanford University. | • Good plugins.  
• Automatic inferencer.  
• Free license. | • Does not support UML. |
| Papyrus    | Last rel Jun ’15.              | • Free license.  
• Supports UML 2.5.  
• Supports OCL.  
• Good community. | • Runs as an extension for eclipse. |
| Modelio    | Last release Nov ’15.          | • Free license.  
• Supports UML 2.  
• Automatic Hibernate Mapping. | • OCL not supported. |
Ontology validation tool

More precisely, validation is understood in this TFG as the process of extracting the data from the VLE and mapping this data to the classes of the ontology. So, this fits the description of an Extracting, Transforming and Loading (ETL) tool. The following solutions have been considered.

Table 14: Ontology validation tool options

<table>
<thead>
<tr>
<th>Name</th>
<th>Main features</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
●User friendly GUI. | ●Completely developed in Java.  
●Desktop application.  
●Works slow with large datasets.  
●Support 24x7 only for licensed users. |
| Cloudera      | Big Data suite.                      | ●Free license.  
●Provides different tools for extract data.  
●Can run pentaho works with a plugin. | ●Needs expensive resources. |

Local database

In order to store the VLE data, for being used in the validation tool, the following solutions have been examined.
Table 15: Local database options

<table>
<thead>
<tr>
<th>Name</th>
<th>Main features</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>mySQL</td>
<td>Relational Database Management System based on SQL.</td>
<td>• It’s easy to find support.</td>
<td>• Not efficient in big data environments.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Table-based database</td>
<td></td>
</tr>
<tr>
<td>HBase</td>
<td>No relational distributed database.</td>
<td>• Fits well in a big data environment.</td>
<td>• Less documentation than mySQL.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stores data in tables and families.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Included in cloudera suite.</td>
<td></td>
</tr>
<tr>
<td>mongoDB</td>
<td>Document-oriented database.</td>
<td>• Efficient in big data environments.</td>
<td>• Join operations in queries not allowed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Easy to install.</td>
<td>• Some disk space limitations in 32-bit systems.</td>
</tr>
</tbody>
</table>

In order to manage the database data during the validation stage, the following solutions have been examined.

Table 16: Local database managing options

<table>
<thead>
<tr>
<th>Name</th>
<th>Main features</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hive</td>
<td>Application for accessing NoSQL databases in a SQL-like way.</td>
<td>• Existence of connectors with mongodb.</td>
<td>• There is little documentation of connectors.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Existence of connectors with HBase.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Included in cloudera suite.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• SQL-like syntax.</td>
<td></td>
</tr>
<tr>
<td>Spark</td>
<td>Java, python or scala library for treating data.</td>
<td>• Existence of connectors with mongodb.</td>
<td>• Long time to learn.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Existence of connectors with HBase.</td>
<td></td>
</tr>
</tbody>
</table>
3.1.2 Election criteria

Due to the needs of the LA4S project, some alternatives had to be chosen as a general agreement of the LA4S developer team. All the final chosen tools are listed below, also with the criteria and if the election was individual or a consensus.

Research and academic articles tools

As mentioned in the methodology section and the previous list of alternatives, this TFG requires to read and study several academic articles. Also, all the documentation has been written with LaTeX code using TeXstudio framework. It was an individual election, so the solution that fitted better is Zotero. Its integration with Bibtex for the LaTeX reference managing, and the Web navigator plugin made the difference among the other tools.

Ontology development

This election was made in a consensus with the directors and the author of this TFG. Owing to the previous knowledge in the language, and the expertise in the field of the director Maria Ribera Sancho, UML was the development language chosen.

Once the language was settled, several software tools were tested. The decision of which one use relapsed to the author of the TFG. Then the most important features to be taken into account were the ease of use with the GUI, the capability of creating associative and n-ary classes, and the existence of a good community support. At first, Papyrus was the option chosen, but as it is explained in the project obstacles section, the final option was Modelio.

Ontology validation tools

So as to validate the ontology through the mapping with a LMS, an ETL suite had to be chosen along with its subsequent tools such as databases or scripting tools.

The first decision the team had to deal with, was the ETL suite. The pilot version of LA4S used Pentaho DI, but the new development version should be based in the Big Data paradigm, then the team chose Cloudera as a data managing tool.

Furthermore, it should be pointed that the data extraction from Departament d’Educació had to be downloaded as a file every morning accessing a web portal. Perl was chosen as a scripting language to retrieve this files. Because these files had the structure of a mongodb export, MongoDB was chosen for storing the moodle database. Also, a script for populating
the mongodb database was coded in **Python**, because of the good performance that the libraries json and pymongo provide. These elections were individual.

In order to manipulate the data in the mongodb database in a proper way, the team chose **Hive** as the solution because it uses SQL Syntax, its ease of use and also has the appropriate libraries to connect with mongodb.

Finally, due to the fact that cloudera provides it, and also Hive is able to interact with it, **HBase** was chosen by the team as the database for storing the data once the ETL has transformed the data into the ontology taxonomy.

### 3.2 Architectural design

Once the alternatives have been listed and evaluated, the final system architecture for the validation was designed. The tools **Zotero, Papyrus** and **Modelio** aren’t included because they supported the development of ontology stage.

The following architecture shows the layers of the whole LA4S proposed system, starting from the mySQL Moodle remote database, and ending with the Dashboard. Layers affecting this TFG are the orange-coloured.

**Figure 4: Architectural design.**
Chapter 4

Proposal of an ontology for modelling and understanding educational data and concepts

4.1 Glossary of terms

**Academic Course**: Period of study in a selection of subjects that are required to complete before moving on to the next level. (definition from edglossary).

**Activity**: Things that people do in order to achieve a particular aim. (definition from longman).

**Assessment**: Wide variety of methods or tools that educators use to evaluate, measure, and document the academic readiness, learning progress, and skill acquisition of students (definition from edglossary).

**Assignment**: A piece of work that a student is asked to do (definition from ).

**Conceptual schema**: High-level description of a business’s informational needs. It typically includes only the main concepts and the main relationships among them. (definition from wikipedia eng).

**Digital footprint**: The information left behind as a result of a user’s web-browsing and stored as cookies. (definition from wikipedia eng).

**Drop-out**: To leave school or college before they have finished. (definition from longman).

**Exam**: a spoken or written test of knowledge, especially an important one (definition from longman).
Learning Analytics: The measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which occurs. (definition from LAK’11).

Learning Event: A learning, training or development activity that has been completed via attendance at a workshop, course or conference or via e-learning, a coaching or mentoring session or a team ‘away day’ or half day etc. (of at least 2 hours duration). In the case of e-learning this may be a cumulative total. (definition from UCL Uk).


Learning Material: A collection of content items, practice items, and assessment items that are combined based on a single learning objective (definition from wikipedia eng).

Learning Metric: Represent granular measurements specific to actions within each genre of activity including all relevant context for any given action on an activity. (definition from IMS Global).

Learning Object: Any entity, digital or non-digital, that may be used for learning, education or training. (definition from IEEE working group).

Learning Objective: Brief statements that describe what students will be expected to learn by the end of school year, course, unit, lesson, project, or class period. (definition from edglossary).

Learning Path: The sum of learning sequences followed by an individual to acquire knowledge, skills or competences. May combine formal and non-formal learning sequences which validation leads to certification. (definition from cedefop).

Lecture: Period of time during which someone teaches a group of people, especially in a school. (definition from longman).

Mood: The way you feel at a particular time. (definition from longman).

Ontology: A set of representational classes, attributes and relationships, with which to model a domain of knowledge or discourse. (definition from Encyclopedia of Database Systems).

Question: A sentence or phrase that is used to ask for information or to test someone’s knowledge. (definition from longman).

Relational Database Management System (RDBMS): Computer software application that interacts with the user, other applications, and the realtional database itself to capture and analyze data. (definition from wikipedia eng).

Resource: Something such as a book, film, or picture used by teachers or students to provide
information. (definition from longman).

**RDF Triple**: an expression linking one object (subject) to another object (object) or a literal via a predicate. (definition from wikipedia english).

**SCORM**: collection of standards and specifications for web-based electronic educational technology (also called e-learning). (definition from wikipedia english).

**Skill**: An ability to do something well, especially because you have learned and practised it. (definition from longman).

**Student**: someone who is studying at a university, school etc (definition from longman).

**Taxonomy**: The process or a system of organizing things into different groups that show their natural relationships. (definition from longman).

**Tracing**: See Digital footprint (definition from ).

**Virtual Learning Environment (VLE)**: a Web-based platform for the digital aspects of courses of study, usually within educational institutions. (definition from wikipedia english).

## 4.2 Specification of the ontology

### 4.2.1 General description

This domain ontology pretends to set an starting point in modelling the learning analytics context. Indeed, learning analytics platforms should map their indicators using the classes of this ontology. So, an ontology of the educational context is going to be proposed and then, concepts of learning analytics will be defined and included on the ontology in the proper way.

Several sources have been reviewed, as can be seen in the section *State of the art*. In fact, this specification uses some concepts already defined in other researches. In any case the source is cited, and if the class of the ontology is derived from the basis source, modifications are properly explained.
Table 17: Summary of sources.

<table>
<thead>
<tr>
<th>Short name</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>LTI v1.2</td>
<td>IMSGlobal Learning Tools Interoperability.</td>
</tr>
<tr>
<td>Caliper v1.0</td>
<td>IMSGlobal Caliper Analytics.</td>
</tr>
<tr>
<td>schema.org</td>
<td>W3C Schema.org Community Group.</td>
</tr>
<tr>
<td>QTI</td>
<td>IMSGlobal Question &amp; Test Interoperability.</td>
</tr>
<tr>
<td>educalab</td>
<td>educaLAB LOM-ES V1.0.</td>
</tr>
<tr>
<td>TinCan</td>
<td>Tin Can xAPI ADL Initiative Vocabulary.</td>
</tr>
</tbody>
</table>

4.2.2 Classes definition

The ontology contains a set of concepts, defined as the following example:

<table>
<thead>
<tr>
<th>Defines the name of the concept</th>
<th>Source: Where it has been retrieved, or taken as a basis for modification.</th>
<th>Superclass: Which class is its parent.</th>
</tr>
</thead>
</table>
| Definition: A little semantic description of the concept. | Attributes: The set of attributes that describes logically the concept. They can be:
   · inherited from its parent (preceded by a hyphen ‘-’).
   · defined in the current class (preceded by a sum symbol ‘+’).
   · derived from other attributes (preceded by a slash ‘\’).
They are also followed by the type of information that the attribute contains. Examples:
- inheritedAttribute: StringType
+ definedAttribute: NumericType
+ /derivedAttribute: ClassType |
| In this cell different annotations are explained. Also, if there were some constraints, they would be noted here. |

All classes belong to a superclass, except for one class (Thing) which is the root class.
<table>
<thead>
<tr>
<th><strong>AcademicCourse</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>LT1 v1.2, modified</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td>A course that follows an established path and fulfil some Educational Goals. (based on LT1 CourseOffering)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Differs from CourseOffering because of the name, which is adapted to the educational context.
<table>
<thead>
<tr>
<th>Source: Caliper v1.0, modified</th>
<th>Superclass: LearningObject</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong> A Learning Object which a user can actively interact with. (based on CaliperAssignable)</td>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>- name: String</td>
<td>- name: String</td>
</tr>
<tr>
<td>- alternateName: String</td>
<td>- alternateName: String</td>
</tr>
<tr>
<td>- description: String</td>
<td>- description: String</td>
</tr>
<tr>
<td>- alternativeHeadline: String</td>
<td>- alternativeHeadline: String</td>
</tr>
<tr>
<td>- dateCreated: DateTime</td>
<td>- dateCreated: DateTime</td>
</tr>
<tr>
<td>- dateModified: DateTime</td>
<td>- dateModified: DateTime</td>
</tr>
<tr>
<td>- datePublished: DateTime</td>
<td>- datePublished: DateTime</td>
</tr>
<tr>
<td>- language: String</td>
<td>- language: String</td>
</tr>
<tr>
<td>- interactivityType: interactivityType</td>
<td>- interactivityType: interactivityType</td>
</tr>
<tr>
<td>- keywords: String</td>
<td>- keywords: String</td>
</tr>
<tr>
<td>- typicalAgeRange: String</td>
<td>- typicalAgeRange: String</td>
</tr>
<tr>
<td>- version: String</td>
<td>- version: String</td>
</tr>
<tr>
<td>- /isLearningObject: Boolean</td>
<td>- /isLearningObject: Boolean</td>
</tr>
<tr>
<td>- content: String</td>
<td>- content: String</td>
</tr>
<tr>
<td>- difficulty: Difficulty</td>
<td>- difficulty: Difficulty</td>
</tr>
<tr>
<td>- interactivityLevel: interactivityLevel</td>
<td>- interactivityLevel: interactivityLevel</td>
</tr>
<tr>
<td>- /available: Boolean</td>
<td>- /available: Boolean</td>
</tr>
<tr>
<td>- /learningObjectType: String</td>
<td>- /learningObjectType: String</td>
</tr>
<tr>
<td>+ compulsory: Boolean</td>
<td>+ compulsory: Boolean</td>
</tr>
<tr>
<td>+ dateToShowOn: DateTime</td>
<td>+ dateToShowOn: DateTime</td>
</tr>
<tr>
<td>+ dateToActivate: DateTime</td>
<td>+ dateToActivate: DateTime</td>
</tr>
<tr>
<td>+ dateToShow: DateTime</td>
<td>+ dateToShow: DateTime</td>
</tr>
<tr>
<td>+ dateToSubmit: DateTime</td>
<td>+ dateToSubmit: DateTime</td>
</tr>
<tr>
<td>+ maxAttempts: Integer</td>
<td>+ maxAttempts: Integer</td>
</tr>
<tr>
<td>+ maxSubmits: Integer</td>
<td>+ maxSubmits: Integer</td>
</tr>
<tr>
<td>+ minScore: Double</td>
<td>+ minScore: Double</td>
</tr>
<tr>
<td>+ maxScore: Double</td>
<td>+ maxScore: Double</td>
</tr>
<tr>
<td>+ activityType: activityType</td>
<td>+ activityType: activityType</td>
</tr>
</tbody>
</table>

Added compulsory and minScore.

**Constraint:** dateModified, dateToShowOn, dateToStartOn, dateToActivate, dateToShow and dateToSubmit can’t be previous to datePublished.

**Constraint:** dateToSubmit can’t be previous to dateToStartOn.

**Constraint:** dateToStartOn can’t be previous to dateToActivate or dateToShow.

**Constraint:** interactivityType can’t be Expositive.

**Constraint:** interactivityLevel can’t be VeryLow.

**Constraint:** minScore must have a value lower than maxScore.
<table>
<thead>
<tr>
<th><strong>Administrator</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
<td>LTI v1.2</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td>User</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>An user who has impact in the learning process and is not a student or a teacher.</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td>- name: String</td>
</tr>
<tr>
<td></td>
<td>- alternateName: String</td>
</tr>
<tr>
<td></td>
<td>- description: String</td>
</tr>
<tr>
<td></td>
<td>- userId: Integer</td>
</tr>
<tr>
<td></td>
<td>- image: String</td>
</tr>
<tr>
<td></td>
<td>- username: String</td>
</tr>
<tr>
<td></td>
<td>- registrationEmail: String</td>
</tr>
<tr>
<td></td>
<td>- org: String</td>
</tr>
<tr>
<td></td>
<td>- userType: userType</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>AreaManager</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
<td>LTI v1.2</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td>Manager</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A manager who supervises the proper functioning of an area.</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td>- name: String</td>
</tr>
<tr>
<td></td>
<td>- alternateName: String</td>
</tr>
<tr>
<td></td>
<td>- description: String</td>
</tr>
<tr>
<td></td>
<td>- userId: Integer</td>
</tr>
<tr>
<td></td>
<td>- image: String</td>
</tr>
<tr>
<td></td>
<td>- username: String</td>
</tr>
<tr>
<td></td>
<td>- registrationEmail: String</td>
</tr>
<tr>
<td></td>
<td>- org: String</td>
</tr>
<tr>
<td></td>
<td>- userType: userType</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td><strong>Source:</strong></td>
<td></td>
</tr>
<tr>
<td>Caliper v1.0</td>
<td></td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td></td>
</tr>
<tr>
<td>Outcome</td>
<td></td>
</tr>
</tbody>
</table>

| **Definition:** |
| Feedback |

| **Attributes:** |
| - name: String |
| - alternateName: String |
| - description: String |
| - normalScore: Double |
| - penaltyScore: Double |
| - extraScore: Double |
| - totalScore: Double |
| - minScore: Double |
| - maxScore: Double |
| - comment: String |
| - dateEvaluated: DateTime |
| + assessmentItem: String |
## Assignment

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th><strong>Superclass:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Caliper v1.0, modified</td>
<td>Exercise</td>
</tr>
</tbody>
</table>

**Definition:**
A task expected to be done by students.

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: Learning-Method
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- /available: Boolean
- /learningObjectType: String
- compulsory: Boolean
- dateToStartOn: DateTime
- dateToActivate: DateTime
- dateToShow: DateTime
- dateToSubmit: DateTime
- maxAttempts: Integer
- maxSubmits: Integer
- minScore: Double
- maxScore: Double
- activityType: activityType
- exerciseType: exerciseType

Class name Assignment taken from Caliper concept Assignable.
<table>
<thead>
<tr>
<th>Book</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>schema.org, modified</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
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<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

In schema.org a Book is a specification of CreativeWork. In this ontology focused in the educational context, a Book is a LearningObject type.

**Constraint:** numberOfPages must be greater than 0.

**Constraint:** interactivityType must be Expositive.

**Constraint:** interactivityLevel must be VeryLow.
<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>QTI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Question</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A question where possible answers are offered.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Attributes:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>- name: String</td>
</tr>
<tr>
<td>- alternateName: String</td>
</tr>
<tr>
<td>- description: String</td>
</tr>
<tr>
<td>- alternativeHeadline: String</td>
</tr>
<tr>
<td>- dateCreated: DateTime</td>
</tr>
<tr>
<td>- dateModified: DateTime</td>
</tr>
<tr>
<td>- datePublished: DateTime</td>
</tr>
<tr>
<td>- language: String</td>
</tr>
<tr>
<td>- interactivityType: interactivityType</td>
</tr>
<tr>
<td>- keywords: String</td>
</tr>
<tr>
<td>- typicalAgeRange: String</td>
</tr>
<tr>
<td>- version: String</td>
</tr>
<tr>
<td>- content: String</td>
</tr>
<tr>
<td>- difficulty: Difficulty</td>
</tr>
<tr>
<td>- instructionalStrategy: LearningMethod</td>
</tr>
<tr>
<td>- interactivityLevel: interactivityLevel</td>
</tr>
<tr>
<td>- typicalLearningTime: Integer</td>
</tr>
<tr>
<td>- /available: Boolean</td>
</tr>
<tr>
<td>- /learningObjectType: String</td>
</tr>
<tr>
<td>- compulsory: Boolean</td>
</tr>
<tr>
<td>- dateToStartOn: DateTime</td>
</tr>
<tr>
<td>- dateToActivate: DateTime</td>
</tr>
<tr>
<td>- dateToShow: DateTime</td>
</tr>
<tr>
<td>- dateToSubmit: DateTime</td>
</tr>
<tr>
<td>- maxAttempts: Integer</td>
</tr>
<tr>
<td>- maxSubmits: Integer</td>
</tr>
<tr>
<td>- minScore: Double</td>
</tr>
<tr>
<td>- maxScore: Double</td>
</tr>
<tr>
<td>- activityType: activityType</td>
</tr>
<tr>
<td>- exerciseType: exerciseType</td>
</tr>
<tr>
<td>- query: String</td>
</tr>
<tr>
<td>- acceptedAnswer: String</td>
</tr>
<tr>
<td>- suggestedAnswer: String</td>
</tr>
<tr>
<td>- questionType: questionType</td>
</tr>
<tr>
<td>+ possibleAnswers: String</td>
</tr>
<tr>
<td>+ /choiceQuestionType: choiceQuestionType</td>
</tr>
</tbody>
</table>

**Constraint:** possibleAnswers must include only one acceptedAnswer.
### Communication

<table>
<thead>
<tr>
<th>Source: own</th>
<th>Superclass: UserInteraction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong> A communication between users. ADLAction type <em>asked, commented or responded</em></td>
<td></td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td></td>
</tr>
<tr>
<td>- name: String</td>
<td></td>
</tr>
<tr>
<td>- alternateName: String</td>
<td></td>
</tr>
<tr>
<td>- description: String</td>
<td></td>
</tr>
<tr>
<td>- id: Integer</td>
<td></td>
</tr>
<tr>
<td>- startDate: DateTime</td>
<td></td>
</tr>
<tr>
<td>- endDate: DateTime</td>
<td></td>
</tr>
<tr>
<td>- language: String</td>
<td></td>
</tr>
<tr>
<td>- location: String</td>
<td></td>
</tr>
<tr>
<td>- eventType: eventType</td>
<td></td>
</tr>
<tr>
<td>- action: LearningAction</td>
<td></td>
</tr>
<tr>
<td>- mood: String</td>
<td></td>
</tr>
<tr>
<td>- info: String</td>
<td></td>
</tr>
<tr>
<td>- /activityTime: Integer</td>
<td></td>
</tr>
<tr>
<td>- /timeUntilAccess: Integer</td>
<td></td>
</tr>
<tr>
<td>+ subject: String</td>
<td></td>
</tr>
<tr>
<td>+ content: String</td>
<td></td>
</tr>
</tbody>
</table>

### CollegeOrUniversity

<table>
<thead>
<tr>
<th>Source: schema.org</th>
<th>Superclass: EducationalOrganization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong> A college, university, or other third-level educational institution.</td>
<td></td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td></td>
</tr>
<tr>
<td>- name: String</td>
<td></td>
</tr>
<tr>
<td>- alternateName: String</td>
<td></td>
</tr>
<tr>
<td>- description: String</td>
<td></td>
</tr>
<tr>
<td>- address: String</td>
<td></td>
</tr>
<tr>
<td>- email: String</td>
<td></td>
</tr>
<tr>
<td>- location: String</td>
<td></td>
</tr>
<tr>
<td>- telephone: String</td>
<td></td>
</tr>
<tr>
<td>- legalName: String</td>
<td></td>
</tr>
<tr>
<td>- /isEducational: Boolean</td>
<td></td>
</tr>
<tr>
<td>- /educationalOrganizationType: String</td>
<td></td>
</tr>
</tbody>
</table>
### ContentDeveloper

**Source:**
LTI v1.2

**Superclass:**
User

**Definition:**
The author of a content.

**Attributes:**
- name: String
- alternateName: String
- description: String
- userId: Integer
- image: String
- username: String
- registrationEmail: String
- org: String
- userType: userType

### Course

**Source:**
LTI v1.2, modified

**Superclass:**
Event

**Definition:**
A series of lessons. (based on LTI CourseTemplate)

**Attributes:**
- name: String
- alternateName: String
- description: String
- id: Integer
- startDate: DateTime
- endDate: DateTime
- language: String
- location: String
- eventType: eventType
- sourcedId: Integer
- label: String
- title: String
- shortDescription: String
- longDescription: String
- courseNumber: Integer
- credits: Integer
- /isAcademic: Boolean

Removed academicSession from this class. Name changed to more Generic Course.
Generalization ser as an Event

**Constraint:**
credits must be greater than 0.
## CourseCoordinator

<table>
<thead>
<tr>
<th>Source:</th>
<th>LT1 v1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Manager</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A manager who supervises the proper functioning of an academic course.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- userId: Integer  
- image: String  
- username: String  
- registrationEmail: String  
- org: String  
- userType: userType |

## CreativeWork

<table>
<thead>
<tr>
<th>Source:</th>
<th>schema.org</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Thing</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The most generic kind of creative work, including books, movies, photographs, software programs, etc.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
+ alternativeHeadline: String  
+ dateCreated: DateTime  
+ dateModified: DateTime  
+ datePublished: DateTime  
+ language: String  
+ interactivityType: interactivityType  
+ keywords: String  
+ typicalAgeRange: String  
+ version: String  
+ /isLearningObject: Boolean |
| **Constraint:** | datePublished and dateModified can’t be previous to dateCreated. |
### Dictionary

**Source:** own  
**Superclass:** Resource

**Definition:**  
A publication with the purpose of defining terms.

**Attributes:**  
- name: String  
- alternateName: String  
- description: String  
- alternativeHeadline: String  
- dateCreated: DateTime  
- dateModified: DateTime  
- datePublished: DateTime  
- language: String  
- interactivityType: interactivityType  
- keywords: String  
- typicalAgeRange: String  
- version: String  
- content: String  
- difficulty: Difficulty  
- instructionalStrategy: LearningMethod  
- interactivityLevel: interactivityLevel  
- typicalLearningTime: Integer  
- available: Boolean  
- learningObjectType: String  
- resourceType: resourceType  
- dictionaryType: dictionaryType

### EducationalGoal

**Source:** own  
**Superclass:** Intangible

**Definition:**  
The learning level to be achieved in a course by a student. (based on LOM Educational Objective)

**Attributes:**  
- name: String  
- alternateName: String  
- description: String  
- sourcedId: Integer  
- shortDescription: String  
- longDescription: String

LOM has the element classification.purpose also known as educational objective. As several classes uses this property, it had become also a class.
<table>
<thead>
<tr>
<th>EducationalOrganization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>schema.org</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
</tbody>
</table>
| An educational organization. | - name: String  
- alternateName: String  
- description: String  
- address: String  
- email: String  
- location: String  
- telephone: String  
- legalName: String  
- /isEducational: Boolean  
+ /educationalOrganizationType: String |

<table>
<thead>
<tr>
<th>ElementarySchool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>schema.org</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
</tbody>
</table>
| A school for students of ages 5 to 12. | - name: String  
- alternateName: String  
- description: String  
- address: String  
- email: String  
- location: String  
- telephone: String  
- legalName: String  
- /isEducational: Boolean  
- /educationalOrganizationType: String  
- /schoolType: String |
<table>
<thead>
<tr>
<th>Source:</th>
<th>Superclass:</th>
</tr>
</thead>
<tbody>
<tr>
<td>schema.org</td>
<td>Thing</td>
</tr>
</tbody>
</table>

**Definition:**
An event happening at a certain time and location, such as a concert, lecture, or festival. Ticketing information may be added via the 'offers' property. Repeated events may be structured as separate Event objects.

**Attributes:**
- name: String
- alternateName: String
- description: String
  + id: Integer
  + startDate: DateTime
  + endDate: DateTime
  + language: String
  + location: String
  + eventType: eventType

**Constraint:** endDate can’t have a value before startDate.
**Exam**

<table>
<thead>
<tr>
<th>Source:</th>
<th>Superclass:</th>
</tr>
</thead>
<tbody>
<tr>
<td>own</td>
<td>Test</td>
</tr>
</tbody>
</table>

**Definition:**
A Test where activities have to be answered by the student to be evaluated. (based on educalab Examen)

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: Learning-Method
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- /available: Boolean
- /learningObjectType: String
- compulsory: Boolean
- dateToStartOn: DateTime
- dateToActivate: DateTime
- dateToShow: DateTime
- dateToSubmit: DateTime
- maxAttempts: Integer
- maxSubmits: Integer
- minScore: Double
- maxScore: Double
## Exercise

<table>
<thead>
<tr>
<th>Source:</th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Activity</td>
</tr>
</tbody>
</table>

### Definition:
A defined task to be done by a learner for assessment or evaluation. (based on educalab *Ejercicio*)

### Attributes:
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: LearningMethod
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- available: Boolean
- learningObjectType: String
- compulsory: Boolean
- dateToStartOn: DateTime
- dateToActivate: DateTime
- dateToShow: DateTime
- dateToSubmit: DateTime
- maxAttempts: Integer
- maxSubmits: Integer
- minScore: Double
- maxScore: Double
- activityType: activityType
  + exerciseType: exerciseType
**Forum**

<table>
<thead>
<tr>
<th>Source:</th>
<th>Superclass:</th>
</tr>
</thead>
<tbody>
<tr>
<td>own</td>
<td>Resource</td>
</tr>
</tbody>
</table>

**Definition:**
A website where users can post messages about a given topic.

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: Learning-Method
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- /available: Boolean
- /learningObjectType: String
- resourceType: resourceType
+ topic: String
<table>
<thead>
<tr>
<th><strong>Glossary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>- name: String</td>
</tr>
<tr>
<td>- alternateName: String</td>
</tr>
<tr>
<td>- description: String</td>
</tr>
<tr>
<td>- alternativeHeadline: String</td>
</tr>
<tr>
<td>- dateCreated: DateTime</td>
</tr>
<tr>
<td>- dateModified: DateTime</td>
</tr>
<tr>
<td>- datePublished: DateTime</td>
</tr>
<tr>
<td>- language: String</td>
</tr>
<tr>
<td>- interactivityType: interactivityType</td>
</tr>
<tr>
<td>- keywords: String</td>
</tr>
<tr>
<td>- typicalAgeRange: String</td>
</tr>
<tr>
<td>- version: String</td>
</tr>
<tr>
<td>- content: String</td>
</tr>
<tr>
<td>- difficulty: Difficulty</td>
</tr>
<tr>
<td>- instructionalStrategy: Learning-Method</td>
</tr>
<tr>
<td>- interactivityLevel: interactivityLevel</td>
</tr>
<tr>
<td>- typicalLearningTime: Integer</td>
</tr>
<tr>
<td>- /available: Boolean</td>
</tr>
<tr>
<td>- /learningObjectType: String</td>
</tr>
<tr>
<td>- dictionaryType: dictionaryType</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
+ sourcedId: Integer  
+ scheme: String  
+ typevalue: String  
+ level: String  
+ email: String  
+ url: String  
+ begin: DateTime  
+ end: DateTime  
+ shortDescription: String  
+ longDescription: String |
| **Constraint:** | end can’t have a value before begin. |

<table>
<thead>
<tr>
<th>HighSchool</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
<td>schema.org</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td>School</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A school for students of ages 15 to 18.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- address: String  
- email: String  
- location: String  
- telephone: String  
- legalName: String  
- /isEducational: Boolean  
- /educationalOrganizationType: String  
- /schoolType: String |
### Instructor

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>LTI v1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>User</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>Someone who teach students</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- userId: Integer  
- image: String  
- username: String  
- registrationEmail: String  
- org: String  
- userType: userType  
+ /isLecturer: Boolean |

### Intangible

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>schema.org</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Thing</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A utility class that serves as the umbrella for a number of 'intangible' things such as quantities, structured values, etc.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String |
### Learner

<table>
<thead>
<tr>
<th>Source:</th>
<th>LearnerSource: LTI v1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>User</td>
</tr>
<tr>
<td>Definition:</td>
<td>A person who wants to learn something.</td>
</tr>
<tr>
<td>Attributes:</td>
<td></td>
</tr>
<tr>
<td>- name: String</td>
<td></td>
</tr>
<tr>
<td>- alternateName: String</td>
<td></td>
</tr>
<tr>
<td>- description: String</td>
<td></td>
</tr>
<tr>
<td>- userId: Integer</td>
<td></td>
</tr>
<tr>
<td>- image: String</td>
<td></td>
</tr>
<tr>
<td>- username: String</td>
<td></td>
</tr>
<tr>
<td>- registrationEmail: String</td>
<td></td>
</tr>
<tr>
<td>- org: String</td>
<td></td>
</tr>
<tr>
<td>- userType: userType</td>
<td></td>
</tr>
<tr>
<td>+ learnerType: LearnerType</td>
<td></td>
</tr>
<tr>
<td>+ /forumAccess: Double</td>
<td></td>
</tr>
<tr>
<td>+ /curiosityRate: Double</td>
<td></td>
</tr>
<tr>
<td>+ /deliveryRate: Double</td>
<td></td>
</tr>
<tr>
<td>+ /learningObjectsAccessed: Double</td>
<td></td>
</tr>
<tr>
<td>+ /numberOfAccesses: Integer</td>
<td></td>
</tr>
<tr>
<td>+ /percentageLearningObjectsAccessed: Double</td>
<td></td>
</tr>
<tr>
<td>+ /isStudent: Boolean</td>
<td></td>
</tr>
</tbody>
</table>

**Constraint:** forumAccess, curiosityRate, deliveryRate and percentageLearningObjectsAccessed must be greater or equal than 0 or less or equal than 1.

**Constraint:** learningObjectsAccessed and numberOfAccesses must be greater or equal than 0.
<table>
<thead>
<tr>
<th><strong>LearningObject</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>- name: String</td>
</tr>
<tr>
<td>- alternateName: String</td>
</tr>
<tr>
<td>- description: String</td>
</tr>
<tr>
<td>- alternativeHeadline: String</td>
</tr>
<tr>
<td>- dateCreated: DateTime</td>
</tr>
<tr>
<td>- dateModified: DateTime</td>
</tr>
<tr>
<td>- datePublished: DateTime</td>
</tr>
<tr>
<td>- language: String</td>
</tr>
<tr>
<td>- interactivityType: interactivityType</td>
</tr>
<tr>
<td>- keywords: String</td>
</tr>
<tr>
<td>- typicalAgeRange: String</td>
</tr>
<tr>
<td>- version: String</td>
</tr>
<tr>
<td>- /isLearningObject: Boolean</td>
</tr>
<tr>
<td>+ content: String</td>
</tr>
<tr>
<td>+ difficulty: Difficulty</td>
</tr>
<tr>
<td>+ instructionalStrategy: LearningMethod</td>
</tr>
<tr>
<td>+ interactivityLevel: interactivityLevel</td>
</tr>
<tr>
<td>+ typicalLearningTime: Integer</td>
</tr>
<tr>
<td>+ /available: Boolean</td>
</tr>
<tr>
<td>+ /learningObjectType: String</td>
</tr>
</tbody>
</table>
### LearningObjectInteraction

<table>
<thead>
<tr>
<th>Source:</th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>An user interaction with the LearningAction type <em>interacted</em>.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- id: Integer  
- startDate: DateTime  
- endDate: DateTime  
- language: String  
- location: String  
- eventType: eventType  
- action: LearningAction  
- mood: String  
- info: String  
- /activityTime: Integer  
- /timeUntilAccess: Integer  
+ learningObjectInteractionType: LearningObjectInteractionType |

**Constraint:** action must have the value *interacted*.

### LearningObjective

<table>
<thead>
<tr>
<th>Source:</th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>Outlines what a student should know and be able to do at the end of each grade. (based on Common Core SS)</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- sourcedId: Integer  
- shortDescription: String  
- longDescription: String  
+ code: String |

To distinguish from the class *Skill*, LearningObjective involves standardized goals.
### LearningPath

**Source:** educalab  
**Superclass:** Intangible  
**Definition:** A set of ordered learning materials. (based on educalab *Secuencia didáctica*)  
**Attributes:**  
- name: String  
- alternateName: String  
- description: String  
+ sourcedId: Integer  

In personalized learning context, this class allows to establish a set of learning objects with the purpose of achieving an Educational Goal.

---

### Lecture

**Source:** own  
**Superclass:** Event  
**Definition:** An event where a lecturer teach students.  
**Attributes:**  
- name: String  
- alternateName: String  
- description: String  
- id: Integer  
- startDate: DateTime  
- endDate: DateTime  
- language: String  
- location: String  
- eventType: eventType
### Lecturer

<table>
<thead>
<tr>
<th>Source:</th>
<th>LT1 v1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Instructor</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>An instructor who teaches in lectures.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- userId: Integer  
- image: String  
- username: String  
- registrationEmail: String  
- org: String  
- userType: userType  
- /isLecturer: Boolean |

### Manager

<table>
<thead>
<tr>
<th>Source:</th>
<th>LT1 v1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>User</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>An user who can manage an educational organization.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- userId: Integer  
- image: String  
- username: String  
- registrationEmail: String  
- org: String  
- userType: userType |
<table>
<thead>
<tr>
<th>MediaOrSliderInteraction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong> own</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
</tbody>
</table>
| A learning object interaction with the learning object interaction type *mediaInteraction* or *sliderInteraction.* | - name: String  
- alternateName: String  
- description: String  
- id: Integer  
- startDate: DateTime  
- endDate: DateTime  
- language: String  
- location: String  
- eventType: eventType  
- action: LearningAction  
- mood: String  
- info: String  
- /activityTime: Integer  
- /timeUntilAccess: Integer  
- learningObjectInteractionType: LearningObjectInteractionType  
  + MediaOrSliderInteractionType: MediaOrSliderInteractionType |

**Constraint:** learningObjectInteractionType must be *mediaInteraction* or *sliderInteraction.*
### Message

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th><strong>Superclass:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>own</td>
<td>Communication</td>
</tr>
</tbody>
</table>

**Definition:**
A private message between two or more users.

**Attributes:**
- name: String
- alternateName: String
- description: String
- id: Integer
- startDate: DateTime
- endDate: DateTime
- language: String
- location: String
- eventType: eventType
- action: LearningAction
- mood: String
- info: String
- /activityTime: Integer
- /timeUntilAccess: Integer
- subject: String
- content: String

### MiddleSchool

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th><strong>Superclass:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>schema.org</td>
<td>School</td>
</tr>
</tbody>
</table>

**Definition:**
A school for students of ages 12 to 15.

**Attributes:**
- name: String
- alternateName: String
- description: String
- address: String
- email: String
- location: String
- telephone: String
- legalName: String
- /isEducational: Boolean
- /educationalOrganizationType: String
- /schoolType: String
<table>
<thead>
<tr>
<th>Source:</th>
<th>QTI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>ChoiceQuestion</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A question where possible answers are offered and many of them can be correct.</td>
</tr>
</tbody>
</table>

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: Learning-Method
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- /available: Boolean
- /learningObjectType: String
- compulsory: Boolean
- dateToStartOn: DateTime
- dateToActivate: DateTime
- dateToShow: DateTime
- dateToShow: DateTime
- dateToSubmit: DateTime
- maxAttempts: Integer
- maxSubmits: Integer
- minScore: Double
- maxScore: Double
- activityType: activityType
- exerciseType: exerciseType
- query: String
- acceptedAnswer: String
- suggestedAnswer: String
- questionType: questionType
- possibleAnswers: String
- choiceQuestionType: choiceQuestionType
+ penalization: Double

**Constraint:** penalization must have a value greater or equal than 0.
**Constraint:** penalization must have a value less or equal than maxScore.
**Constraint:** possibleAnswers must include at least one acceptedAnswer.
<table>
<thead>
<tr>
<th><strong>Definition:</strong></th>
<th><strong>Attributes:</strong></th>
</tr>
</thead>
</table>
| A question that expects a text written by a student as answer. | - name: String  
- alternateName: String  
- description: String  
- alternativeHeadline: String  
- dateCreated: DateTime  
- dateModified: DateTime  
- datePublished: DateTime  
- language: String  
- interactivityType: interactivityType  
- keywords: String  
- typicalAgeRange: String  
- version: String  
- content: String  
- difficulty: Difficulty  
- instructionalStrategy: LearningMethod  
- interactivityLevel: interactivityLevel  
- typicalLearningTime: Integer  
- /available: Boolean  
- /learningObjectType: String  
- compulsory: Boolean  
- dateToStartOn: DateTime  
- dateToActivate: DateTime  
- dateToShow: DateTime  
- dateToSubmit: DateTime  
- maxAttempts: Integer  
- maxSubmits: Integer  
- minScore: Double  
- maxScore: Double  
- activityType: activityType  
- exerciseType: exerciseType  
- query: String  
- acceptedAnswer: String  
- suggestedAnswer: String  
- questionType: questionType  
+ limitNumber: Integer  
+ limitType: String |
### Organization

<table>
<thead>
<tr>
<th>Source:</th>
<th>schema.org</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>An organization such as a school, NGO, corporation, club, etc.</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td>Thing</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
  + address: String  
  + email: String  
  + location: String  
  + telephone: String  
  + legalName: String  
  + /isEducational: Boolean |

### Outcome (Associative Class)

<table>
<thead>
<tr>
<th>Source:</th>
<th>Caliper v1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>The process of giving a value judgement of a done work. (based on Caliper Result)</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td>Intangible</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
  + normalScore: Double  
  + penaltyScore: Double  
  + extraScore: Double  
  + totalScore: Double  
  + minScore: Double  
  + maxScore: Double  
  + comment: String  
  + dateEvaluated: DateTime |

Caliper has the entity Result in the Outcome Metric Profile. As an Assessment is also an Outcome, this class name describes the purpose of our ontology concept. Also added dateEvaluated and minScore attributes.

**Constraint:** minScore, maxScore, normalScore, penaltyScore and extraScore must be greater or equal than 0.

**Constraint:** maxScore must be greater or equal than minScore.

**Constraint:** normalScore must be greater or equal than minScore and less or equal than maxScore.

**Constraint:** totalScore must be the sum of normalScore and extraScore minus penaltyScore.
<table>
<thead>
<tr>
<th>Person</th>
<th>Preschool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>LTI v1.2 + schema.org</td>
<td>schema.org</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td><strong>Superclass:</strong></td>
</tr>
<tr>
<td>Thing</td>
<td>EducationalOrganization</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td>A person (alive, dead, undead, or fictional).</td>
<td>A educational organization for children up to 5 years.</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>- name: String</td>
<td>- name: String</td>
</tr>
<tr>
<td>- alternateName: String</td>
<td>- alternateName: String</td>
</tr>
<tr>
<td>- description: String</td>
<td>- description: String</td>
</tr>
<tr>
<td>+ sourcedId: Integer</td>
<td>- address: String</td>
</tr>
<tr>
<td>+ name.full: String</td>
<td>- email: String</td>
</tr>
<tr>
<td>+ address.street1: String</td>
<td>- location: String</td>
</tr>
<tr>
<td>+ address.street2: String</td>
<td>- telephone: String</td>
</tr>
<tr>
<td>+ address.locality: String</td>
<td>- legalName: String</td>
</tr>
<tr>
<td>+ address.country: String</td>
<td>- /isEducational: Boolean</td>
</tr>
<tr>
<td>+ phone.mobile: String</td>
<td>- /educationalOrganizationType: String</td>
</tr>
<tr>
<td>+ phone.home: String</td>
<td></td>
</tr>
<tr>
<td><strong>Source:</strong></td>
<td>own</td>
</tr>
<tr>
<td>-------------</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Superclass:</strong></td>
<td>Communication</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A message sent in a forum.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- id: Integer  
- startDate: DateTime  
- endDate: DateTime  
- language: String  
- location: String  
- eventType: eventType  
- action: LearningAction  
- mood: String  
- info: String  
- /activityTime: Integer  
- /timeUntilAccess: Integer  
- subject: String  
- content: String |
<table>
<thead>
<tr>
<th><strong>Question</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>schema.org - QTI</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td>A specific question - e.g. from a user seeking answers online, or collected in a Frequently Asked Questions (FAQ) document. - An exercise defined by a query, where its answer is expected for evaluation.</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

In schema.org is a specialization of CreativeWork, but in this educational context is modified and its generalization is Exercise.
<table>
<thead>
<tr>
<th>Source:</th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>Test</td>
</tr>
<tr>
<td>Definition:</td>
<td>A Test with only choice-type questions. (based on educalab Cuestionario)</td>
</tr>
</tbody>
</table>
| Attributes: | - name: String  
- alternateName: String  
- description: String  
- alternativeHeadline: String  
- dateCreated: DateTime  
- dateModified: DateTime  
- datePublished: DateTime  
- language: String  
- interactivityType: interactivityType  
- keywords: String  
- typicalAgeRange: String  
- version: String  
- content: String  
- difficulty: Difficulty  
- instructionalStrategy: Learning-Method  
- interactivityLevel: interactivityLevel  
- typicalLearningTime: Integer  
- /available: Boolean  
- /learningObjectType: String  
- compulsory: Boolean  
- dateToStartOn: DateTime  
- dateToActivate: DateTime  
- dateToShow: DateTime  
- dateToSubmit: DateTime  
- maxAttempts: Integer  
- maxSubmits: Integer  
- minScore: Double  
- maxScore: Double  
+ penaltyScore: Double  
+ weight: Double |

**Constraint:** penaltyScore and weight must be greater or equal than 0.
<table>
<thead>
<tr>
<th><strong>Resource</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong> own</td>
</tr>
<tr>
<td><strong>Superclass:</strong> LearningObject</td>
</tr>
<tr>
<td><strong>Definition:</strong> A Learning Object which a user can access with a low interaction.</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>- name: String</td>
</tr>
<tr>
<td>- alternateName: String</td>
</tr>
<tr>
<td>- description: String</td>
</tr>
<tr>
<td>- alternativeHeadline: String</td>
</tr>
<tr>
<td>- dateCreated: DateTime</td>
</tr>
<tr>
<td>- dateModified: DateTime</td>
</tr>
<tr>
<td>- datePublished: DateTime</td>
</tr>
<tr>
<td>- language: String</td>
</tr>
<tr>
<td>- interactivityType: interactivityType</td>
</tr>
<tr>
<td>- keywords: String</td>
</tr>
<tr>
<td>- typicalAgeRange: String</td>
</tr>
<tr>
<td>- version: String</td>
</tr>
<tr>
<td>- /isLearningObject: Boolean</td>
</tr>
<tr>
<td>- content: String</td>
</tr>
<tr>
<td>- difficulty: Difficulty</td>
</tr>
<tr>
<td>- instructionalStrategy: LearningMethod</td>
</tr>
<tr>
<td>- interactivityLevel: interactivityLevel</td>
</tr>
<tr>
<td>- typicalLearningTime: Integer</td>
</tr>
<tr>
<td>- /available: Boolean</td>
</tr>
<tr>
<td>- /learningObjectType: String</td>
</tr>
<tr>
<td>+ resourceType: resourceType</td>
</tr>
</tbody>
</table>

**Constraint:** interactivityType must be Expositive or Mixed.
<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th><strong>Superclass:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>schema.org</td>
<td>EducationalOrganization</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Definition:</strong></th>
<th><strong>Attributes:</strong></th>
</tr>
</thead>
</table>
| A school. | - name: String  
- alternateName: String  
- description: String  
- address: String  
- email: String  
- location: String  
- telephone: String  
- legalName: String  
- /isEducational: Boolean  
- /educationalOrganizationType: String  
+ /schoolType: String |
<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>QTI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>ChoiceQuestion</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>A question where possible answers are offered and only one of them can be correct.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- alternativeHeadline: String  
- dateCreated: DateTime  
- dateModified: DateTime  
- datePublished: DateTime  
- language: String  
- interactivityType: interactivityType  
- keywords: String  
- typicalAgeRange: String  
- version: String  
- content: String  
- difficulty: Difficulty  
- instructionalStrategy: Learning-Method  
- interactivityLevel: interactivityLevel  
- typicalLearningTime: Integer  
- /available: Boolean  
- /learningObjectType: String  
- compulsory: Boolean  
- dateToStartOn: DateTime  
- dateToActivate: DateTime  
- dateToShow: DateTime  
- dateToShow: DateTime  
- maxAttempts: Integer  
- maxSubmits: Integer  
- minScore: Double  
- maxScore: Double  
- activityType: activityType  
- exerciseType: exerciseType  
- query: String  
- acceptedAnswer: String  
- suggestedAnswer: String  
- questionType: questionType  
- possibleAnswers: String  
- choiceQuestionType: choiceQuestionType |
| **Constraint:** | Only one acceptedAnswer must be included in possibleAnswers. |
### Skill

<table>
<thead>
<tr>
<th>Source: own</th>
<th>Superclass: EducationalGoal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>A competence that can be acquired by learning. (based on educalab taxonomy Competencia)</td>
<td>- name: String</td>
</tr>
<tr>
<td></td>
<td>- alternateName: String</td>
</tr>
<tr>
<td></td>
<td>- description: String</td>
</tr>
<tr>
<td></td>
<td>- sourcedId: Integer</td>
</tr>
<tr>
<td></td>
<td>- shortDescription: String</td>
</tr>
<tr>
<td></td>
<td>- longDescription: String</td>
</tr>
</tbody>
</table>

### SoftwareApplication

<table>
<thead>
<tr>
<th>Source: schema.org</th>
<th>Superclass: CreativeWork</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td><strong>Attributes:</strong></td>
</tr>
<tr>
<td>A software application.</td>
<td>- name: String</td>
</tr>
<tr>
<td></td>
<td>- alternateName: String</td>
</tr>
<tr>
<td></td>
<td>- description: String</td>
</tr>
<tr>
<td></td>
<td>- alternativeHeadline: String</td>
</tr>
<tr>
<td></td>
<td>- dateCreated: DateTime</td>
</tr>
<tr>
<td></td>
<td>- dateModified: DateTime</td>
</tr>
<tr>
<td></td>
<td>- datePublished: DateTime</td>
</tr>
<tr>
<td></td>
<td>- language: String</td>
</tr>
<tr>
<td></td>
<td>- interactivityType: interactivityType</td>
</tr>
<tr>
<td></td>
<td>- keywords: String</td>
</tr>
<tr>
<td></td>
<td>- typicalAgeRange: String</td>
</tr>
<tr>
<td></td>
<td>- version: String</td>
</tr>
<tr>
<td></td>
<td>+ applicationCategory: String</td>
</tr>
<tr>
<td></td>
<td>+ applicationSuite: String</td>
</tr>
<tr>
<td></td>
<td>+ availableOnDevice: String</td>
</tr>
<tr>
<td></td>
<td>+ releaseNotes: String</td>
</tr>
<tr>
<td></td>
<td>+ softwareVersion: String</td>
</tr>
<tr>
<td>Source:</td>
<td>Superclass:</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>own</td>
<td>Learner</td>
</tr>
</tbody>
</table>

**Definition:**
A learner who has a learning path assigned, and some educational goals to fulfill.

**Attributes:**
- name: String
- alternateName: String
- description: String
- userId: Integer
- image: String
- username: String
- registrationEmail: String
- org: String
- learnerType: LearnerType
- userType: userType
- /forumAccess: Double
- /curiosityRate: Double
- /deliveryRate: Double
- /learningObjectsAccessed: Double
- /numberOfAccesses: Integer
- /percentageLearningObjectsAccessed: Double
- /isStudent: Boolean
### Subject

**Source:** own  
**Superclass:** Thing

**Definition:**  
A structured set of learning units of the same knowledge domain. (based on LTI CourseSection)

**Attributes:**
- name: String  
- alternateName: String  
- description: String  
  + sourcedId: Integer  
  + label: String  
  + title: String  
  + shortDescription: String  
  + longDescription: String  
  + maxNumberOfStudents: Integer  
  + numberOfStudents: Integer  
  + subjectDifficulty: Difficulty  
  + credits: Integer

**Constraint:** maxNumberOfStudents must have a value greater than 0.  
**Constraint:** numberOfStudents must have a value greater or equal than 0 and less or equal than maxNumberOfStudents.  
**Constraint:** credits must have a value greater or equal than 0.

### SystemAdministrator

**Source:** LT1 v1.2  
**Superclass:** Administrator

**Definition:**  
An administrator who cares about the VLE or LMS.

**Attributes:**
- name: String  
- alternateName: String  
- description: String  
- userId: Integer  
- image: String  
- username: String  
- registrationEmail: String  
- org: String  
- userType: userType
<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th><strong>Superclass:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>QTI</td>
<td>Activity</td>
</tr>
</tbody>
</table>

**Definition:**
A set of exercises to be done for assessment or evaluation.

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: LearningMethod
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- /available: Boolean
- /learningObjectType: String
- compulsory: Boolean
- dateToStartOn: DateTime
- dateToActivate: DateTime
- dateToShow: DateTime
- dateToShow: DateTime
- dateToSubmit: DateTime
- maxAttempts: Integer
- maxSubmits: Integer
- minScore: Double
- maxScore: Double
- activityType: activityType
+ /testType: String
<table>
<thead>
<tr>
<th>Thesaurus</th>
<th>Source: own</th>
<th>Superclass: Dictionary</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Thing</th>
<th>Source: schema.org</th>
<th>Superclass: -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition: The most generic type of item.</td>
<td>Attributes: + name: String + alternateName: String + description: String</td>
<td></td>
</tr>
<tr>
<td><strong>Unit</strong></td>
<td><strong>User</strong></td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Source:</strong> LTI v1.2</td>
<td><strong>Source:</strong> LTI v1.2</td>
<td></td>
</tr>
<tr>
<td><strong>Superclass:</strong> Thing</td>
<td><strong>Superclass:</strong> Intangible</td>
<td></td>
</tr>
<tr>
<td><strong>Definition:</strong> A set of resources of the same topic. (based on LTI CourseSection)</td>
<td><strong>Definition:</strong> A person who is registered and can use a service.</td>
<td></td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td><strong>Attributes:</strong></td>
<td></td>
</tr>
<tr>
<td>- name: String</td>
<td>- name: String</td>
<td></td>
</tr>
<tr>
<td>- alternateName: String</td>
<td>- alternateName: String</td>
<td></td>
</tr>
<tr>
<td>- description: String</td>
<td>- description: String</td>
<td></td>
</tr>
<tr>
<td>+ sourcedId: Integer</td>
<td>+ userld: Integer</td>
<td></td>
</tr>
<tr>
<td>+ label: String</td>
<td>+ image: String</td>
<td></td>
</tr>
<tr>
<td>+ title: String</td>
<td>+ username: String</td>
<td></td>
</tr>
<tr>
<td>+ shortDescription: String</td>
<td>+ registrationEmail: String</td>
<td></td>
</tr>
<tr>
<td>+ longDescription: String</td>
<td>+ org: String</td>
<td></td>
</tr>
<tr>
<td>+ unitNumber: Integer</td>
<td>+ userType: userType</td>
<td></td>
</tr>
<tr>
<td>+ credits: Integer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ dept: String</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ begin: DateTime</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ end: DateTime</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Constraint:** end can’t be previous to begin.

**Constraint:** credits must have a value greater or equal than 0.
<table>
<thead>
<tr>
<th>Source:</th>
<th>schema.org, modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>Event</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>An interaction between a user and an object.</td>
</tr>
</tbody>
</table>
| **Attributes:** | - name: String  
- alternateName: String  
- description: String  
- id: Integer  
- startDate: DateTime  
- endDate: DateTime  
- language: String  
- location: String  
- eventType: eventType  
+ action: LearningAction  
+ mood: String  
+ info: String  
+ /activityTime: Integer  
+ /timeUntilAccess: Integer |

Taking into account the class UserInteraction in schema.org, two more attributes are added: action and mood.

**Constraint:** activityTime must be greater or equal than 0.

**Constraint:** timeUntilAccess must be greater or equal than 0.
<table>
<thead>
<tr>
<th><strong>VirtualLearningEnvironment</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source:</strong></td>
</tr>
<tr>
<td>own</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
</tr>
<tr>
<td>An online platform with the function of supporting the learning process. (based on educalab Herramienta de gestión de aprendizaje)</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
### WebApplication

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th><strong>Superclass:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>schema.org</td>
<td>SoftwareApplication</td>
</tr>
</tbody>
</table>

**Definition:**
A web application.

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- applicationCategory: String
- applicationSuite: String
- availableOnDevice: String
- releaseNotes: String
- softwareVersion: String
+ browserRequirements: String
### Wiki

<table>
<thead>
<tr>
<th>Source</th>
<th>Superclass: Dictionary</th>
</tr>
</thead>
<tbody>
<tr>
<td>educalab</td>
<td></td>
</tr>
</tbody>
</table>

**Definition:**
A collaborative website where authors define terms.

**Attributes:**
- name: String
- alternateName: String
- description: String
- alternativeHeadline: String
- dateCreated: DateTime
- dateModified: DateTime
- datePublished: DateTime
- language: String
- interactivityType: interactivityType
- keywords: String
- typicalAgeRange: String
- version: String
- content: String
- difficulty: Difficulty
- instructionalStrategy: Learning-Method
- interactivityLevel: interactivityLevel
- typicalLearningTime: Integer
- /available: Boolean
- /learningObjectType: String
- dictionaryType: dictionaryType

### 4.2.3 Enumerations

An enumeration is a list whose attributes are the values which a variable can take.

<table>
<thead>
<tr>
<th>ActivityType</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source: own</td>
</tr>
</tbody>
</table>

**Definition:**
The type of the Activity

**Attributes:**
- Exercise
- Test
### choiceQuestionType

<table>
<thead>
<tr>
<th>Source</th>
<th>Superclass</th>
</tr>
</thead>
<tbody>
<tr>
<td>own</td>
<td>Enumeration</td>
</tr>
</tbody>
</table>

**Definition:**
The type of the choiceQuestion

**Attributes:**
- MultiChoiceQuestion
- SingleChoiceQuestion

### DictionaryType

<table>
<thead>
<tr>
<th>Source</th>
<th>Superclass</th>
</tr>
</thead>
<tbody>
<tr>
<td>own</td>
<td>Enumeration</td>
</tr>
</tbody>
</table>

**Definition:**
The type of the Dictionary

**Attributes:**
- Glossary
- Thesaurus
- Wiki

### Difficulty

<table>
<thead>
<tr>
<th>Source</th>
<th>Superclass</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOM</td>
<td>Enumeration</td>
</tr>
</tbody>
</table>

**Definition:**
How hard it is to work through the learning object for the typical target audience.

**Attributes:**
- VeryEasy
- Easy
- Medium
- Difficult
- VeryDifficult

### EventType

<table>
<thead>
<tr>
<th>Source</th>
<th>Superclass</th>
</tr>
</thead>
<tbody>
<tr>
<td>own</td>
<td>Enumeration</td>
</tr>
</tbody>
</table>

**Definition:**
The type of the Event

**Attributes:**
- Course
- Lecture
- UserInteraction
### ExerciseType

<table>
<thead>
<tr>
<th>Source:</th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The type of the Exercise</td>
</tr>
</tbody>
</table>
| **Attributes:** | + Question  
+ Assignment |

### InteractivityLevel

<table>
<thead>
<tr>
<th>Source:</th>
<th>LOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>Level of interactivity between an end user and the learning object.</td>
</tr>
</tbody>
</table>
| **Attributes:** | + VeryLow  
+ Low  
+ Medium  
+ High  
+ VeryHigh |

### InteractivityType

<table>
<thead>
<tr>
<th>Source:</th>
<th>LOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The type of interactivity supported by the learning object.</td>
</tr>
</tbody>
</table>
| **Attributes:** | + Active  
+ Expositive  
+ Mixed  
+ Undefined |
<table>
<thead>
<tr>
<th>Source:</th>
<th>TinCan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superclass:</td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>What is done in the interaction</td>
</tr>
</tbody>
</table>
| **Attributes:** | + abandoned  
+ accepted  
+ accessed  
+ added  
+ answered  
+ appended  
+ archived  
+ asked  
+ assigned  
+ attached  
+ attempted  
+ canceled  
+ closed  
+ commented  
+ completed  
+ confirmed  
+ created  
+ deleted  
+ delivered  
+ exited  
+ experienced  
+ failed  
+ favorited  
+ imported  
+ initialized  
+ inserted  
+ interacted  
+ joined  
+ launched  
+ opened  
+ passed  
+ posted  
+ progressed  
+ registered  
+ responded  
+ resolved  
+ resumed  
+ saved  
+ scored  
+ searched  
+ sent  
+ shared  
+ submitted  
+ suspended  
+ terminated  
+ used  
+ waived |
### LearnerType

<table>
<thead>
<tr>
<th>Source:</th>
<th>Educalab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>The type of a student.</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td>+ Student + SpecialNeedsLearner + GiftedLearner + StudentWithLateIntegrationIntoSystem + StudentWithOtherSpecificEducationalSupportNeeds + GeneralPublic</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source:</th>
<th>Educalab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Enumeration</td>
</tr>
</tbody>
</table>

### LearningMethod

<table>
<thead>
<tr>
<th>Source:</th>
<th>Educalab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>The paradigm where is based the design of the learning objects.</td>
</tr>
<tr>
<td><strong>Attributes:</strong></td>
<td>+ Exposition + CaseBased + ProblemBased + ObjectiveBased + Simulation + ProjectBased + Collaborative + Investigation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source:</th>
<th>Educalab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Enumeration</td>
</tr>
</tbody>
</table>
### LearningObjectInteractionType

<table>
<thead>
<tr>
<th>Source: LOM</th>
<th>Superclass: Enumeration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>An action performed by a user with a learning object.</td>
</tr>
</tbody>
</table>
| **Attributes:** | + associateInteraction  
+ choiceInteraction  
+ customInteraction  
+ drawingInteraction  
+ endAttemptInteraction  
+ extendedTextInteraction  
+ gapMatchInteraction  
+ graphicAssociateInteraction  
+ graphicGapMatchInteraction  
+ graphicOrderInteraction  
+ hotspotInteraction  
+ hottextInteraction  
+ inlineChoiceInteraction  
+ matchInteraction  
+ mediaInteraction  
+ orderInteraction  
+ positionObjectInteraction  
+ selectPointInteraction  
+ sliderInteraction  
+ textEntryInteraction  
+ uploadInteraction |

### MediaOrSliderInteractionType

<table>
<thead>
<tr>
<th>Source: imsglobal</th>
<th>Superclass: Enumeration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Definition:</strong></td>
<td>The flow control of the action.</td>
</tr>
</tbody>
</table>
| **Attributes:** | + Start  
+ Finish  
+ Resume  
+ Cancel  
+ SkipForward  
+ SkipBackward  
+ Undefined |
### QuestionType

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The type of the Question</td>
</tr>
</tbody>
</table>
| **Attributes:** | + choiceQuestion  
+ openQuestion |

### ResourceType

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The type of the Resource</td>
</tr>
</tbody>
</table>
| **Attributes:** | + Book  
+ Dictionary  
+ Forum |

### UserType

<table>
<thead>
<tr>
<th><strong>Source:</strong></th>
<th>own</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superclass:</strong></td>
<td>Enumeration</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The type of the User</td>
</tr>
</tbody>
</table>
| **Attributes:** | + Administrator  
+ SystemAdministrator  
+ Instructor  
+ Learner  
+ ContentDeveloper  
+ Manager  
+ CourseCoordinator  
+ AreaManager |

#### 4.2.4 Associations

The ontology also includes a set of relations between concepts, and are defined as follows:

**association name:**

Class1 (role_name_class1) multiplicity_class1 - multiplicity_class2 (role_name_class2) Class2

Semantic meaning of the association.
Multiplicity can take the following values: 0..1, *, 1..*

achieves:

\textit{AcademicCourse (academicCourse) * - * (educationalGoal) EducationalGoal}

The educational goals that a student achieves passing the academic course.

attendsTo:

\textit{Student (student) * - * (lecture) Lecture}

The lectures that a student assist to.

assignedTo:

\textit{Student (student) * - * (learningPath) LearningPath}

Specifies in whichs Learning Paths is the student assigned.

cites:

\textit{CreativeWork (creativeWork) * - * (citation) CreativeWork}

The creative works that are cited by another creative work.

diposesOf:

\textit{Unit (unit) * - * (learningObject) LearningObject}

Set of learning objects that belong to an unit.

employedIn:

\textit{Person (employee) * - * (organization) Organization}

Specified the organization where the person is employed.

enrolledOn:

\textit{Student (student) * - * (academicCourse) AcademicCourse}

The academic courses that a student is enrolled on.

evaluate:

\textit{User (user) * - * (userInteraction) UserInteraction}

The outcome associated to an interaction.

follows:

\textit{Event (previousEvent) * - * (nextEvent) Event}

What events are previous to the current one.

formedBy:

\textit{Group (group) * - 1..* (learner) Learner}

The set of learners that form the group.

fulfills:

\textit{LearningObject (learningObject) * - * (educationalGoal) EducationalGoal}

Which learning objects are to be completed to achieve the educational goal.
hasAsVLE:
Course (course) * - * (virtualLearningEnvironment) VirtualLearningEnvironment
Which VLE’s are the support for the learning.

hasChoiceQuestions:
Quiz (Quiz) * - * (choiceQuestion) ChoiceQuestion
Specifies the order of the learning objects in a learning path.

hasExercises:
Test (test) * - * (exercise) Exercise
What exercises are in the test.

hasNext:
LearningObject (previous) * - * (next) LearningObject
Specifies the order of the learning objects in a learning path.

hasParentOrganization:
Organization (subOrganization) * - * (parentOrganization) Organization
Which sub-organizations belong to a parent organization.

hasToFulfill:
Student (student) * - * (educationalGoal) EducationalGoal
Which educational goals has the student to fulfill.

inscribedIn:
Learner (learner) * - * (course) Course
The courses in which a learner is enrolled.

interacts:
User - DateTime - LearningObject
The interactions that a user has performed with a learning object.

isAlumniOf:
Person (alumni) * - * (educationalOrganization) EducationalOrganization
Establishes where a Person has studied.

isAuthorOf:
ContentDeveloper (author) * - * (creativeWork) CreativeWork
Which creative works has the author developed.

isDepartmentOf:
Organization (department) * - 0..1 (organization) Organization
Defines the organization where the department belongs to.

isHomeworkFor:
LearningObject (homework) * - * (futureLecture) Lecture
The contents which are expected to be done before the given lecture.

isPostedIn:
Post (post) * - 1 (forum) Forum
Specifies in which forum has the post been sent.

isRegisteredIn:
User (registeredUser) * - * (VirtualLearningEnvironment) VirtualLearningEnvironment
The VLE’s where the users are registered at.

isTaughtIn:
Unit (unit) * - * (lecture) Lecture
In which lectures is the unit taught.

isTeacherOf:
Instructor (instructor) * - * (subject) Subject
In which subjects can the teacher teach.

isUsedIn:
LearningObject (learningObject) * - * (lectureUsed) Lecture
In which lectures is the learning object used.

manages:
Manager (manager) 1..* - * (managedEducationalOrganization) EducationalOrganization
Specifies which courses are offered in an educational organization.

offersCourse:
EducationalOrganization (educationalOrganization) * - * (course) Course
Specifies which courses are offered in an educational organization.

offersAcademicCourse:
School (school) * - * (academicCourse) AcademicCourse
Specifies which Academic Courses are offered in a School.

organizedBy:
Organization (organizer) * - * (event) Event
Establishes what organization has organized an event.

organizes:
Person (personOrganizer) * - * (event) Event
Establishes who has organized an event.

registeredAs:
Person (person) 1 - * (user) User
To which person belongs the user.

`replied`:
*Post (reply) * - 0..1 (post) Post*
Defines which post replies the first one.

`senteTo`:
*Message (message) * - 1..* (receiver) User*
The receiver of the message.

`supervises`:
*CourseCoordinator (courseCoordinator) * - * (academicCourse) AcademicCourse*
Specifies which academic courses are supervised by the Course Coordinator.

`teaches`:
*Instructor (teacher) * - * (taughtLecture) Lecture*
The lectures a teacher has taught.

### 4.2.5 Aggregations

`hasSubjects`:
*AcademicCourse (academicCourse) * -o * (subject) Subject*
The set of Subjects that compound an Academic Course.

`hasUnits`:
*Subject (subject) * -o * (unit) Unit*
Which units compound the specified subject.

`isPartOfEvent`:
*Event (bigEvent) 0..1 o- * (event) Event*
Defines an event by composing other events.

`listOf`:
*LearningPath (learningPath) * -o 1..* (learningObject) LearningObject*
What ordered list of learning objects compound the learning path.

### 4.2.6 Constraints

**Foreign Key Constraints**

(FK1) (Person, sourcedId)
General constraints

(IC1) A Manager who manages an EducationalOrganization, must be a User registeredAs the Person (employee) employedIn a Organization.

(IC2) A Learner who is inscribedIn a Course, must be a User registeredAs the Person (alumni) that isAlumniOf an EducationalOrganization that offers the Course.

(IC3) A User that isRegisteredIn a VirtualLearningEnvironment, is also inscribedIn the Course that hasAsVLE the previous VirtualLearningEnvironment.

(IC4) If a Course is an AcademicCourse, then the EducationalOrganization which offers the course is a School.

(IC5) There can’t be more than one instances of User who isRegisteredIn a VirtualLearningEnvironment with the same username or userid.

(IC6) A Student can only interact with the LearningObjects that are of the Unit, that is of the Subject of the AcademicCourse that the Student is enrolledOn

(IC7) If a LearningObject isUsedIn a Lecture, then the Unit which disposesOf the LearningObject isTaughtIn the same Lecture.

(IC8) An Instructor teaches Lectures of the Units of the Subjects where the Instructor isTeacherOf.
(IC9) A Student attends to the Lectures of the Units and Subjects of the Academic-Course in which the Student is enrolled on.

(IC10) A LearningPath is a list of ordered LearningObjects following the hasNext association.

(IC11) A Student enrolled on an AcademicCourse has_to_fulfill the EducationalGoals that the AcademicCourse achieves.

(IC12) A User can only evaluate the UserInteractions of a User that is_registered_in the same VirtualLearningEnvironment.

(IC13) A LearningObject can only fulfill EducationalGoals achieved on the AcademicCourse which hasSubjects that hasUnits that disposesOf the named LearningObject.

(IC14) If a Test is a Quiz, the instances of hasChoiceQuestions, must be a set of the instances of hasExercises.

(IC15) An UserInteraction becomes a Communication when the action is answered, asked, commented, joined, posted, registered, responded or sent.

(IC16) An UserInteraction becomes a LearningObjectInteraction when the action is interacted.

(IC17) A LearningObjectInteraction becomes a MediaOrSliderInteraction when the learningObjectInteractionType is mediaInteraction or sliderInteraction.

(IC18) A Message can only be sent to a receiver who is_registered_in the same Virtual-LearningEnvironment.

(IC19) A Post can only be replied with a reply that is_posted_in the same instance of Forum.

Derivation Rules

(DR1) An Organization isEducational and becomes an EducationalOrganization if there are some instances of offersCourse associated to the Organization.

(DR2) The educationalOrganizationType is Preschool, School or CollegeOrUniversity if the Courses offered by the EducationalOrganization are AcademicCourses.

(DR3) The schoolType of a School is defined by the courseNumber of the Academic-Course that are offered. Between 1 and 6 is a Elementary School, between 7 and 10 is a Middle School and between 11 and 12 is High School.

(DR4) A CreativeWork isLearningObject if it can be assigned to a Unit of a Subject
of a Course.

(DR5) A Course is Academic if it achieves some LearningObjectives.

(DR6) A LearningObject’s learningObjectType is an Activity if its InteractivityType is Active or Mixed, or is a Resource if its InteractivityType is Expositive.

(DR7) A Test has testType Quiz if all the Exercises it has are ChoiceQuestions. Otherwise, a Test has testType Exam if it fulfills some LearningObjectives.

(DR8) An Instructor is Lecturer if it has instances of teaches with a Lecture.

(DR9) A Learner is Student if it is inscribedIn an AcademicCourse.

4.2.7 Modelling LA4S concepts

The LA4S project defines currently 7 indicators of motivation which will be explained on this chapter. Once defined, it will be explained how they have been integrated in the ontology.

In order to clarify what the LearningAction defines, the following words have the same meaning:

- **accessed** = initialized, opened, launched, resumed, used.
- **abandoned** = canceled, closed, waived.
- **completed** = delivered, failed, passed, resolved, submitted, suspended, terminated.

Furthermore, and as can be seen in the conceptual schema, a UserInteraction is an Event, and Events can be part of bigger Events. So, an UserInteraction with the action attempted will be performed when an UserInteraction with an accessed action attribute is followed by an UserInteraction with an abandoned or completed action attribute.
**Figure 5:** Flow of attempted

**Sheets of the indicators**

The following tables are based on the **UNE 66175:2003 standard of indicators definition**, taking into account the most notable properties.
<table>
<thead>
<tr>
<th><strong>Name:</strong> Forum Access</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code:</strong> LA1</td>
</tr>
<tr>
<td><strong>Description:</strong> For every forum in the course, how many had been accessed by the student.</td>
</tr>
<tr>
<td><strong>Main source:</strong> Learner, Student</td>
</tr>
<tr>
<td><strong>Presentation:</strong> 0 ≤ x ≤ 1</td>
</tr>
<tr>
<td><strong>Calculation:</strong> Calculated by dividing the sum of all the <em>Forums</em> that have at least one <em>UserInteraction</em> with the <em>LearningAction</em> accessed, between the sum of all the accessible <em>Forums</em>.</td>
</tr>
</tbody>
</table>
| \[
\frac{\sum \text{ (Available forums accessed at least one time)}}{\sum \text{ (Available forums in the course)}}
| **Example:** In a subject with 8 forums, the student has accessed 5 of these forums. |
| \[
\frac{5}{8} = 0.625
| **Table 18:** Forum Access indicator definition. |

<table>
<thead>
<tr>
<th><strong>Name:</strong> Curiosity Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code:</strong> LA2</td>
</tr>
<tr>
<td><strong>Description:</strong> For every non-compulsory activity in the context, how many have been accessed by the student.</td>
</tr>
<tr>
<td><strong>Main source:</strong> Learner, Student</td>
</tr>
<tr>
<td><strong>Presentation:</strong> 0 ≤ x ≤ 1</td>
</tr>
<tr>
<td><strong>Calculation:</strong> Calculated by dividing the sum of all the <em>Activity</em> with the attribute <em>compulsory</em> as false that have at least one <em>UserInteraction</em> of the User.</td>
</tr>
</tbody>
</table>
| \[
\frac{\sum \text{ (Non-compulsory Activities accessed)}}{\sum \text{ (Non-compulsory Activities available)}}
| **Example:** In a subject with 46 learning objects, there are 28 non-compulsory, and the student has accessed 21 of these learning objects. |
| \[
\frac{21}{28} = 0.75
| **Table 19:** Curiosity Rate indicator definition. |
**Name:** Delivery Rate

**Code:** LA3

**Description:** For every compulsory activity available to the student, how many have been delivered by the student.

**Main source:** Student, Learner

**Presentation:** $0 \leq x \leq 1$

**Calculation:** Calculated by dividing the sum of all the Activity with the attributes compulsory and available as true that have at least one UserInteraction with the LearningAction completed.

\[
\frac{\sum \text{(Compulsory Activities finished)}}{\sum \text{(Compulsory Activities available)}}
\]

**Example:** In an academic course with 60 learning objects, there are 24 compulsory, and the student has accessed 22 of these learning objects, having completed 20.

\[
\frac{20}{24} = 0.83
\]

*Table 20: Delivery Rate indicator definition.*
<table>
<thead>
<tr>
<th>Name</th>
<th>Activity Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>LA4</td>
</tr>
<tr>
<td>Description</td>
<td>For every activity, how much time did the student invest in it.</td>
</tr>
<tr>
<td>Main source</td>
<td>UserInteraction</td>
</tr>
<tr>
<td>Presentation</td>
<td>$0 \leq x \leq \infty$</td>
</tr>
</tbody>
</table>
| Calculation   | Calculated by summing the differences resulting by subtracting the $DateTime$ of the association with the $UserInteraction$ attribute $action$ as abandoned or completed, from the $DateTime$ of the association with the $UserInteraction$ attribute $action$ as accessed.  
\[
\sum_{n=1}^{\text{attempts}} \left(\text{DateTime(abandoned,completed)} - \text{DateTime(accessed)}\right)
\] |
| Example       | A student interacts with a Quiz as follows: Access at 1pm, abandones at 2pm, resumes at 2:30pm, abandones at 3pm, resumes at 5pm and completes at 6pm. \((2 - 1) + (3 - 2.5) + (6 - 5) = 2.5 \text{ hours}\) |

*Table 21: Activity Time indicator definition.*
**Name:** Percentage of learning objects accessed

**Code:** LA5  
**Description:** For every learning object, how many has the student accessed.  
**Main source:** Learner, Student  
**Presentation:** $0 \leq x \leq 1$

**Calculation:** Calculated by dividing the sum of all the Learning Object with the attribute available as true that have at least one UserInteraction with the action accessed, into the total amount of available Learning Objects.

$$\frac{\sum \text{(Learning Object accessed)}}{\sum \text{(Learning Object available)}}$$

**Example:** In a subject with 75 available learning objects, the student has accessed 42 different learning objects.

$$\frac{42}{75} = 0.56$$

*Table 22: Percentage of learning objects accessed indicator definition.*

---

**Name:** Number of accesses

**Code:** LA6  
**Description:** For every learning object available, how many times has it been accessed by the student.  
**Main source:** Learner, Student  
**Presentation:** $0 \leq x \leq \infty$

**Calculation:** Calculated by summing the amount of UserInteractions, with the action accessed, of that User in a LearningObject.

$$\sum \text{Learning Object accessed}$$

**Example:** In a subject with a Quiz, a Dictionary and a Resource, the user has accessed 4 times the Quiz, 1 time the dictionary and 2 times the Resource.

$$4 + 1 + 2 = 7 \text{ times}$$

*Table 23: Number of accesses indicator definition.*
**Name:** Time until first access

**Code:** LA7

**Description:** For every learning object in the context, how much time took the student to access it for the first time.

**Main source:** UserInteraction

**Presentation:** $0 \leq x \leq \infty$

**Calculation:** Calculated by taking the UserInteraction with the minimum timeUntilAccess. The attribute timeUntilAccess is computed by subtracting the DateTime of the UserInteraction from the DatePublished of the CreativeWork.

\[
\min(\text{timeUntilAccess})
\]

**Example:** The teacher published a Learning Object at 4pm, and the student did 3 accesses: at 6pm, at 6:30pm and at 8pm.

\[
\min((6 - 4), (6.5 - 4), (8 - 4)) = 2 \text{ hours}
\]

*Table 24: Time until first access indicator definition.*

## Integration of the learning analytics concepts

All these indicators have been properly added in the ontology as follows:

- LA1: derived attribute `forumAccess` in class `Learner`.
- LA2: derived attribute `curiosityRate` in class `Learner`.
- LA3: derived attribute `deliveryRate` in class `Learner`.
- LA4: derived attribute `activityTime` in class `UserInteraction`.
- LA5: derived attribute `percentageLearningObjectsAccessed` in class `Learner`.
- LA6: derived attribute `numberOfAccesses` in class `Learner`.
- LA7: uses derived attribute `timeUntilAccess` in class `UserInteraction`.

For computing the `percentageLearningObjectsAccessed`, the derived attribute `learningObjectsAccessed` was added to the class `Learner`. 

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4.2.8 Conceptual schema

The whole conceptual schema has been added as the appendix Conceptual Schema.

Taxonomies

![Taxonomy of Thing](image1)

*Figure 6: Taxonomy of Thing.*

![Taxonomy of Person](image2)

*Figure 7: Taxonomy of Person.*

![Taxonomy of Intangible](image3)

*Figure 8: Taxonomy of Intangible.*
Figure 9: Taxonomy of User.

Figure 10: Taxonomy of Organization.
Figure 11: Taxonomy of CreativeWork.

Figure 12: Taxonomy of SoftwareApplication.
Figure 13: Taxonomy of LearningObject.
Figure 14: Taxonomy of Event.

Figure 15: Taxonomy of EducationalGoal.

Figure 16: Taxonomy of Outcome.
Parts of the whole schema

Figure 17: Section of the conceptual schema (Person, EducationalOrganization, Course, User and VLE.)
Figure 18: Section of the conceptual schema (Learner, Instructor, LearningObject, Subject and Lecture.)
Figure 19: Section of the conceptual schema (UserInteraction, LearningObject.)
4.3 Theoretical validation

In order to evaluate and validate the correctness of the ontology, a framework is going to be applied. This framework is specific for evaluating the quality of domain ontologies for web-based learning[2], and consists in a set of questions to be answered with a score as the following table stipulates:

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither Agree or disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

The questions intend to evaluate five quality goals of the ontology: theoretical completeness, consistency, conciseness, preciseness and clarity.

4.3.1 Theoretical completeness

- Are all general domain concepts covered by ontology? 3
- Are all subconcepts specified down to the required granularity? 2
- Are all relations between domain concepts specified? 4
- Are all necessary disjointness relations specified? 4
- Do all entities from subject domain have relation to ontology concepts? 4
- Does ontology deal well with known good resources about preferred domain? 2

4.3.2 Consistency

- Are all definitions consistent? 3
- Are there no contradictory information? 4
- Can contradictory information be inferred from present definitions and axioms? 3
4.3.3 Conciseness

Is there no concept or property, which is explicitly declared and also can be inferred?  4
Are there no unnecessary information or details?  4

4.3.4 Preciseness

Are subclassing axioms correct?  4
Are axioms about equivalent classes correct?  4
Are axioms about disjoint classes correct?  4
Are there other types of relations other than subsumption?  4
Are domains and ranges of object properties defined correctly?  2
Is transitivity of object properties correct?  4
Are object properties defined at necessary level?  3
Is symmetry of object properties correct?  3
Are data properties defined correctly?  3
Is data range for data properties defined correctly?  2
Are instances asserted correctly (as instances of appropriate class)?  4
Are object property assertions stated correctly?  0
Are data property assertions stated correctly?  0
Are there no class with only one subclass?  0
Are types (classes) and instances not confused?  4
Are classes defined in other way than directly?  4
Are there no loops in definitions?  4

4.3.5 Clarity

Is terminology coherent?  4
Is uniform notation used?  4
Are labels constructed according to preferred rules?  2
### 4.3.6 Total

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theoretical completeness</td>
<td>3.16</td>
</tr>
<tr>
<td>Consistency</td>
<td>3.33</td>
</tr>
<tr>
<td>Conciseness</td>
<td>4</td>
</tr>
<tr>
<td>Preciseness</td>
<td>2.88</td>
</tr>
<tr>
<td>Clarity</td>
<td>3.33</td>
</tr>
</tbody>
</table>

In summary, the ontology is theoretically complete, consistent, concise and clear. It only has an issue on preciseness because there are classes with only one subclass, and there are not assertions.
Chapter 5

Implementation with a Virtual Learning Environment

5.1 A study of the implementation between a VLE and the platform

In this chapter, the ontology is going to be mapped to the Moodle schema, but the result of this TFG is generic and is suitable to any VLE. According to that, the ontology may be mapped to any other LMS, resulting in different processes to retrieve data.

An ontology provides a defined and unambiguous vocabulary for domain experts, and is allowed to be extended with new concepts and relationships, but doesn’t allow changing what is already defined. This means that the ontology -understood as the set of classes, relations and constraints- along with the data of a VLE database and the definition of some rules, composes a knowledge base where the information can be easily retrieved. Ontologies and databases are complementary: databases are efficient at storing large volumes of data, ontologies are good at reasoning about the information stored in the database.

One of the most important steps during the implementation of the ontology is the mapping between the ontology itself and the database instances of the VLE. It involves recognizing concepts or relationships when performing a schema analysis of the database. This process can be performed manually (for instance, the validation through an implementation of this chapter), or can be done in a semi-automatic way using some of the available tools [31] [32] [33] [34]. In any case, the mapping process will require to analyze how the ontology schema concepts are represented in the VLE database schema. Then, build the knowledge base, by correctly mapping the ontology concepts against the instances of the VLE. Furthermore, this process may also involve extending the model merging or extending it with other ontologies.
O. Romero and A. Abelló propose an automatic multidimensional design of data warehouses from ontologies (AMDO) [35] to identify, for each ontology concept, its potential measures and dimensional concepts by using search patterns and filtering functions. The drawback of this solution is that it would take an extra step, yet contemplated in his research, due to a pre-process of generating an OWL DL ontology from the UML or ER diagram. This pre-process can be done with several methods [36] and can also be automated [37] [38].

5.2 Validation through the implementation with Agora

This section includes the validation of the completeness of the ontology, through an implementation of the corresponding knowledge base within a LMS. This knowledge base is understood as a mapping of the ontology concepts against the instances corresponding to the data stored in the LMS database.

5.2.1 Process of implementation

Extraction of LMS database

As Agora is the LMS used by schools in the pilot LA4S project, this will be the chosen LMS. It is a Moodle-based solution developed by UPCNet1 and widely used in Catalonia, with more than 1.300 schools using it. Hence, a data extraction of the Agora database of a school, also used in the LA4S, will be taken as the database.

Every day the extraction file is uploaded to a web portal. This extraction file has as many json rows as sql records are in the tables of the Agora database, an example:

1  
{"id": "441", "contextlevel": "70", "instanceid": "161", "table": "context"}  
2  
{"id": "124", "fullname": "Tecnologia ESO 2B-2D", "table": "course"}

In the example of the extraction above, the first line corresponds to one record of the table context with the three columns id, contextlevel and instance with the values 441, 70 and 161 respectively. The second line corresponds to one record of the table course with the columns id and fullname, with the values 124 and "Tecnologia ESO 2B-2D" respectively.

The extraction file is loaded into a mongoDB database through a Python script2. This MongoDB instance has a database with the code of the school, and a different collection3

1http://www.upcnet.es/referencies/campus-virtual-gencat
2Additional results chapter, Python script for populating a mongoDB from an export section.
3MongoDB context for grouping documents, similar to tables in RDBMS.
for every different table value in the extraction. For instance, in the school with code 286 there are 20 collections:

- assign (id, name, course, timemodified)
- assign_submission (id, userid, assignment, timecreated)
- context (id, instanceid, contextlevel)
- course (id, fullname)
- course_modules (id, course, module, instance, added)
- course_sections (id, course, section, name)
- files (id, userid, timecreated, timemodified, status)
- folder (id, course, name, timemodified)
- forum (id, course, name, timemodified)
- jcl (id, course, name, timeavailable, timedue)
- label (id, course, name, timemodified)
- log (id, course, userid, module, cmid, time, action)
- logstore_standard_log (id, courseid, userid, contextid, timecreated, objectid, objecttable, crud, component, contextinstanceid, contextlevel, eventname, action, edulevel)
- modules (id, name)
- quiz (id, course, name, timecreated, timeopen, timemodified, timeclose)
- resource (id, course, name, timemodified)
- role (id, shortname)
- role_assignments (id, userid, contextid, roleid)
- url (id, course, name, timemodified)
- wiki (id, course, name, timecreated, timemodified)

So as to properly query the MongoDB database, Hive provides the capabilities of retrieving the data in a similar way to SQL queries. The community provides a series of libraries for
enable Hive to connect with a MongoDB instance \(^4\). So, once placed in the right paths, a database named as agora concatenated with the school code (for instance, agora286) is created, and the tables are created using the next example:

```sql
1 CREATE DATABASE IF NOT EXISTS agora286;
2 USE agora286;
3 CREATE EXTERNAL TABLE IF NOT EXISTS course
4 ( id INT,
5   fullname STRING
6 )
7 STORED BY 'com.mongodb.hadoop.hive.MongoStorageHandler'
8 WITH SERDEPROPERTIES('mongo.columns.mapping'="'id':"id",
9   "fullname":"fullname"")
10 TBLPROPERTIES('mongo.uri'='mongodb://127.0.0.1:27017/286.assign');
```

At this point, the Agora database is able to be queried.

**Knowledge base classes storage**

One of the main questions of this TFG is how the knowledge base of the ontology will be stored. UML Classes are translated to Data Classes with an id as a Primary Key. On the other hand, every many-to-many UML association will conform also a Data Class with the two foreign keys of the UML class as a composed primary key. For example, the following UML association:

![Figure 20: Fulfills relation in the ontology.](https://github.com/mongodb/mongo-hadoop/wiki/Hive-Usage)

Is represented as

\(^4\)https://github.com/mongodb/mongo-hadoop/wiki/Hive-Usage
5.2.2 Validation

Following the *agora286* example of this section, the knowledge base is conformed by mapping the following ontology concepts to the extracted tables of the LMS:

![Diagram of the Fulfill relation in the knowledge base.](image)
### Table 26: Agora school 286 mapping.

<table>
<thead>
<tr>
<th>Ontology concept</th>
<th>LMS Source tables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>assign, jclic, quiz, course_modules, context, course</td>
</tr>
<tr>
<td>Assignment</td>
<td>assign, course_modules, context, course</td>
</tr>
<tr>
<td>CreativeWork</td>
<td>assign, files, folder, forum, jclic, quiz, url, wiki, course_modules, context, course</td>
</tr>
<tr>
<td>Dictionary</td>
<td>wiki, course_modules, context, course</td>
</tr>
<tr>
<td>Event</td>
<td>log, logstore_standard_log, role, role_assignments</td>
</tr>
<tr>
<td>Exercise</td>
<td>jclic, course_modules, context, course</td>
</tr>
<tr>
<td>Forum</td>
<td>forum, course_modules, context, course</td>
</tr>
<tr>
<td>hasUnits</td>
<td>course, course_sections</td>
</tr>
<tr>
<td>Instructor</td>
<td>role, role_assignments</td>
</tr>
<tr>
<td>Learner</td>
<td>role, role_assignments</td>
</tr>
<tr>
<td>LearningObject</td>
<td>assign, files, folder, forum, jclic, quiz, url, wiki, course_modules, context, course</td>
</tr>
<tr>
<td>Person</td>
<td>role, role_assignments</td>
</tr>
<tr>
<td>Quiz</td>
<td>quiz, course_modules, context, course</td>
</tr>
<tr>
<td>registeredAs</td>
<td>role, role_assignments</td>
</tr>
<tr>
<td>Resource</td>
<td>url, folder, files, forum, wiki, course_modules, context, course</td>
</tr>
<tr>
<td>Student</td>
<td>role, role_assignments</td>
</tr>
<tr>
<td>Subject</td>
<td>course</td>
</tr>
<tr>
<td>Test</td>
<td>quiz, course_modules, context, course</td>
</tr>
<tr>
<td>Unit</td>
<td>course, course_sections</td>
</tr>
<tr>
<td>User</td>
<td>role, role_assignments</td>
</tr>
<tr>
<td>UserInteraction</td>
<td>log, logstore_standard_log, role, role_assignments</td>
</tr>
<tr>
<td>Wiki</td>
<td>wiki, course_modules, context, course</td>
</tr>
</tbody>
</table>

The appendix Hive Script got mapping the ontology to Agora contains the Hive script which builds the knowledge base based on the ontology, of the school 286.

As a knowledge base has been built with the proposed ontology and the instances of a LMS, this knowledge base **validates the completeness** of the ontology.
Chapter 6

Project Obstacles

6.1 LA4S project everyday work

Owing to the fact of being a member of a team, during September and October I had to introduce two new members of the project team to the LA4S topic. So, I did a briefing on the topic and supported them during their environment setup. This meant that some human resources were assigned to tasks that were not strictly of this TFG during the first months.

Also, LA4S team was represented in Jornades TIC UPC with a Poster of what is being developed in the project. So, the 2nd task of the development "Acquire knowledge about ontologies and Learning Analytics" increased the amount of hours due to this reason, allowing me to improve the Introduction section of this report.

6.2 Problems with UML tool Papyrus

On 12th January, the file which contained the Papyrus UML project was corrupted, and no backup was available. Therefore, the ontology development software tool had to be changed to Modelio causing an increase of hours in the 7th task "Develop the Ontology".

6.3 Continuous appearance of studies

There is a lack of documentation in UML Ontologies, specially of Learning Analytics ontologies. The nature of research projects involves a component of uncertainty, that is why the 2nd, 4th and 5th tasks of the development stage had their time increased from what had
been estimated.

While developing the first concepts of the ontology, around November '15, new learning products were coming to scene. For example Caliper Analytics, which is introduced in the state of the art, was not taken into account at the beggining of the development. As it used a specific set of concepts, they had to be studied and included in the ontology, delaying the development and adding new references to study. For this reason, the task 6 "Research about existent ontologies in learning context" increased its hours.

6.4 Data extraction issues

The team expected to have direct connection to Agora database in order to access the data, but instead of that, a dump file had to be downloaded from Departament d’Educació and loaded into a local database. As a solution, three scripts were developed: a first one in perl to automate the downloading of the file, a second one also in perl for populating the MySQL local database, and a third one in python for populate the local MongoDB database. This is included in the task 3 "Develop data processing scripts" of the development stage.

6.5 Environment set-up issues

The whole LA4S environment (including Cloudera Suite), was available on the first week of February. Then, the implementation of the ontology with the Agora data could start. For this reason, the report writing task was started at this point until the environment was correctly configured instead of the 8th task "Implement the ontology with Agora database".

Also, due to the lack of documentation, it took a week to configure the connection between Hive and MongoDB. Finally, a solution that fitted to our set-up was found but, due to the inLab’s security policy in the development servers, the team did not have root privileges to accomplish the proposed solution by itself so, help from inLab system administrators was needed. For this reason, there is an increase of hours in the first task of the Final Stage "Validation".
Chapter 7

Future Work

7.1 Translate to other formal ontology languages

Ontologies are also coded in formal languages like RDF, or OWL. Furthermore, some frameworks are capable of translating from UML to OWL. This would boost the standardization of this ontology to be more accepted in the domain.

7.2 Extension of the ontology

As long as new studies are appearing, the ontology may be updated with new concepts that will be introduced. Also, new learning analytics indicators can be defined, developed and included in this ontology.

7.3 Mapping new knowledge bases

The validation of this TFG has been done through an implementation of a particular knowledge base, using the data of two subjects of the school IES Juan Manuel Zafra. The LA4S project can access the data of more schools, then the mapping of the implementation done in this TFG can be extended with the concepts represented in these other schools.
7.4 Proposal for publishing the results

Dra. Maria Ribera Sancho has proposed to develop a proposal for standardization, and publish the results of this TFG as an academic publication. They would be available to the learning analytics community.

Society for Learning Analytics Research (SOLAR) publishes the Journal of Learning Analytics, which is a peer-reviewed, open-access journal. This could be the target journal for submitting our proposal.
Chapter 8

Additional results

In order to validate the ontology, some tools have been developed to process the data. These tools are considered part of the TFG development because they were necessary to achieve some objectives. Also, a significant part of the time has been employed to develop these tools.

8.1 Perl script for downloading files

Once a day, a file with a extraction of the moodle database of every centre had to be downloaded from the Agora web portal of the Departament d’Educació. To automate this process, a script coded in Perl was developed.

The main features included the use of the Mechanize library to automatically login and navigate through the portal, a regular expression parser to find the file matching the current day, the download of the file, and the process of extraction from tar-gzip format to json.

The code is attached in the appendix named Perl script for downloading files.

8.2 Perl script for populating a SQL database from MongoDB file

Before the migration from Pentaho environment to Cloudera architecture, the json file with the extraction downloaded previously had to be loaded into a mysql database. To automate this process after downloading of the file, a script was developed also in Perl language. The algorithm processes every line one by one.
The main features of the script are:

- Getting value from the *table* key.
- Checking if the *table* exists and creates it from the key names.
- Checking if all the columns exists in the *table*, and adds the necessaries with their type.
- Inserting the row to the given *table* checking if the type is INT or STRING.
- If there are successive lines with the same *table* value, they are processed faster.

The code is attached in the appendix named *Perl script for populating a SQL database from MongoDB file*.

### 8.3 Python script for populating a mongoDB from an export

The readLines.pl script was replaced by a Python script with the same purpose. It only changed on the output towards a mongoDB database.

The code is attached in the appendix named *Python script for populating a mongoDB*.
Chapter 9

Integration of knowledge

9.1 Integration of knowledge and competences from GEI

Throughout my degree studies, I have learnt from different computer science fields, and specially of Information Systems. So, the following list indicates the most important skills, learnt from the subjects of the degree, applied to this TFG.

- **ER**: Requirements engineering skills.
- **MI**: How to develop indicators.
- **ABD**: Database administration skills. OLAP Analysis skills.
- **PSI**: Project planning skills.
- **ASO**: Server-side administration. UNIX skills.
- **WSE**: Writing skills in English.
- **ASDP**: How to develop and perform an oral presentation in English.

9.2 Valoration of technical competences of the project

- CSI1: Demostrar comprensió i aplicar els principis i les pràctiques de les organitzacions, de manera que puguin exercir d’enllaç entre les comunitats tècnica i de gestió d’una organització, i participar activament en la formació dels usuaris. [Bastant]
So as to understand Learning Analytics domain, it must be learnt how Educational Organizations are managed, how students learn and how they use their Learning Management System. An ontology also merges the concepts of developers’ domain with the concepts of users’ domain.

- **CSI2.1**: Demostrar comprensió i aplicar els principis i les tècniques de gestió de qualitat i d’innovació tecnològica a les organitzacions. [Bastant]

This project surely has an innovation component, because there is not a functional ontology in this area of knowledge. In order to achieve this goal, several databases of academic articles have been used for searching publications. Also quality evaluation frameworks have been used for evaluating the ontology.

- **CSI2.2**: Concebre, desplegar, organitzar i gestionar sistemes i serveis informàtics, en contextos empresarials o institucionals, per a millorar-ne els processos de negoci; responsabilitzar-se’n i liderar-ne la posada en marxa i la millora contínua; valorar el seu impacte econòmic i social. [Bastant]

The ontology will be validated through its the implementation in the LA4S project, improving its platform. It will also be released to the Learning Analytics community, and will help educational organizations to track the students’ motivation.

- **CSI2.3**: Demostrar coneixement i capacitat d’aplicació dels sistemes d’extracció i de gestió del coneixement. [En profunditat]

An ETL tool will be used to extract the data from Moodle Database. As additional results, some data extraction scripts have been developed and are available in the appendix.

- **CSI2.4**: Demostrar coneixement i capacitat d’aplicació dels sistemes basats en Internet (e-commerce, e-learning, etc.). [En profunditat]

In order to develop this TFG properly, expertise on an e-learning system database, as Moodle, must be learnt. This is also a thorough research on the e-learning and educational context.

- **CSI2.6**: Demostrar coneixement i capacitat d’aplicació dels sistemes d’ajuda a la presa de decisions i de business intelligence. [En profunditat]

This TFG is a business intelligence project within a decision-making aid system. Moreover, KPI’s of students motivation will be developed.

- **CSI4.1**: Participar activament en l’especificació dels sistemes d’informació i de comunicació. [En profunditat]

The development of this ontology itself is a specification of an Information System,
and will be part of the Learning Analytics for Secondary Dashboard.

- CSI4.2: Participar activament en el disseny, la implementació i el manteniment dels sistemes d’informació i de comunicació. [En profunditat]

This ontology will be the domain layer of the Learning Analytics for Secondary Project. During weekly meetings I proposed several alternatives to the team, some of which became part of the architecture design, which then I had to implement.

- CSI4.3: Administrar bases de dades (CES1.6). [Una mica]

This TFG requires to administrate different database technologies, such as MySQL, MongoDB, Hive, HDFS and HBase. It has been learnt how to install, configure and manage this database technologies.
Chapter 10

Conclusions

The main goals of this TFG have been To develop an ontology for the Educational Context domain, particularly on Learning Analytics domain, and To map the concepts of the Learning Analytics ontology with Moodle Database (Agora). As seen in chapter 4 (Proposal of an ontology for modelling and understanding educational data and concepts), and in chapter 5 (Implementation with a Virtual Learning Environment), both of them have been achieved.

During the development of this TFG, the methodology used has helped to keep the aim on focus. So, choosing agile methodologies has been a good election because they allowed to manage deviations in an easier way, as for instance in the named in the chapter 6 (Project Obstacles). Moreover, as exposed in section 2.3 (Differences between initial and final project planning), these deviations have had an impact on increasing initial time planning and budget, but were insurmountable. Thus, our weekly meetings helped to properly manage the whole project. For example, in these meetings we made all the team decisions, and we examined the possibilities for solving the deviations. So, it would have been an error changing the methodology during the development.

The proposed solution had to take into account the copyright issues. All the solutions of IMSGlobal needed for a Registration in their site\(^1\), specifically the third (3. Grant of License to Copy and Distribute) and the fourth (4. Grant of License to Develop Products Based on the Specification(s)) sections. Additionally, other specifications are bound by a Creative Commons 3.0 license (freely shareable and adaptable).

To conclude, and as explained in section 7.4 (Proposal for publishing the results), the results may be published in an academic paper in collaboration with Dra. Maria Ribera Sancho. These results accomplish the policy recommendations for learning analytics stated by Learning Analytics Community Exchange (LACE) in July 2015, and also expects to fill the

\(^1\)http://www.imsglobal.org/speclicense.html
requirements, which the Learning Analytics field claims, for a standard way of modelling and collecting data cited in the section 1.2 (Formulation of the problem).
Bibliography


[23] J. Murphy, N. Kalbaska, L. Horton-Tognazzini, and L. Cantoni, “Online Learning and


Appendix A

Conceptual Schema
Appendix B

Perl script for downloading files

The following script coded in Perl takes an argument for the school id in Agora Database of Departament d’Educació.
Usage example:
$ perl get_file 1152

```perl
#!/usr/bin/perl
use strict;
use warnings;
use LWP;
use WWW::Mechanize;
use POSIX 'strftime';
use LWP::Simple;
use Archive::Tar;

my $schoolid = $ARGV[0];
my $username = "*****";
my $password = "*****";
my $mech = WWW::Mechanize->new(noproxy =>'0');
my $url = 'http://*****/portal/index.php?module=fitxers&type=user&func=main&folder=usu'.$schoolid;
print "Acces a $url \n";
#$mech->get($url);
my $i = 1;
```
$mech->get($url);
while ($mech->status != 200) {
    print ($mech->status . "at $i time \n")
    $mech->get($url);
}

$mech->form_name('users_login_login_form');
$mech->field('authentication_info[login_id]' => "$username");
$mech->field('authentication_info[pass]' => "$password");
$mech->submit_form() or die "Form not submittd \n\n";

#print('http://www.google.com')
my $document = $mech->content();
my $ymd = strftime '%Y%m%d', localtime;
print ('AVUI: ' . $ymd . "\n")
## AFEGIT DE http://lwp.interglacial.com/ch06_06.htm
while ($document =~ m/href\s*=\s*"([\^\"\s\+]).tgz+"/gi) {
    my $absolute_url = absolutize($1, $url);
    if ($absolute_url =~ $ymd) {
        check_url($absolute_url . "\".tgz");
        my $urlDownload = $absolute_url . ".tgz";
        my $localFile = "D:/SOFT/bigData.tgz";
        getstore($urlDownload, $localFile) or die "File has not been downloaded.\n\n";
        my $tar = Archive::Tar->new($localFile);
        #$tar->read($localFile);
        #$tar->extract();
        foreach my $member ($tar->list_files()) {
            my $res = $tar->extract_file($member,
            'D:/USUARIS/jordi.casanovas/Desktop/GatLab-LA/LA/WebContent/WEB-INF/\' . $school . ".json'
            );
            print "Exract error!\n" unless ($res);
        }
        print "DESCOMPRIMIT! \n"
    }
}
sub absolutize {
    my($url, $base) = @_;  
    use URI;  
    return URI->new_abs($url, $base)->canonical;  
}

sub check_url {
    print "Baixant l'arxiu $_[0]\n";
}

#open(OUTFILE, ">$outfile");  
#print OUTFILE "$response";  
#close(OUTFILE);
Appendix C

Perl script for populating a SQL database from MongoDB file

The following script coded in Perl takes an argument for the school id in Agora Database of Departament d’Educació, and adds it to the local filename downloaded with getFile.pl
Usage example:
$ perl readLines 1152

```perl
#!/usr/bin/perl
use strict;
use warnings;
use JSON;
use Try::Tiny;
use DBI;
use DBD::mysql;
use Scalar::Util;
use 5.010;

my $schoolid;
$schoolid = $ARGV[0];
my $file
    = 'D:\USUARIS\jordi.casanovas\Desktop\GatLab-LA\LA\WebContent\WEB-INF\'.$schoolid.'.json'
open(INFO, $file) or die("Could not open file.");
my $count = 0;
my $errors = 0;
my $line = "";
my $decoded;
```
my $database = '*****';
my $hostname = 'w***.fib.upc.edu';
my $port = *****;
my $dsn = "DBI:mysql:database=$database;host=$hostname;port=$port";
my $username = '*****';
my $password = '*****';

$db = DBI->connect($dsn, $username, $password) or die $DBI::errstr;
$db->{mysql_enable_utf8} = 1;
$db->do("SET NAMES UTF8");

my $table;
my $lastTable = "";
my $prefix = "mdl_";

foreach $line (<INFO>) {
    $count++;
    try {
        my %decoded = %{
            JSON::XS::decode_json($line)
        };
        $table = $prefix . $decoded{table};
        delete $decoded{table};
        %decoded = %{
            addSchoolPrefix(%decoded, $table, $schoolid)
        };
        if ($lastTable eq $table){
            #print "$count: DIRECTE $table, %decoded\n\n";
            insertDirect($table, %decoded);
        }else{
            #print "$count: COMPLET $table, %decoded\n\n";
            insert($table, %decoded);
        }
    #print "\n";
    } catch {
        warn "Caught JSON::XS decode error: $_";
        $errors++;
    };
    $lastTable = $table;
}
$db -> disconnect;

sub addSchoolPrefix{
    my ($obj, $table, $prefix) = @_;
    my $key = "";
    my $value = ""
    while (my ($key, $value) = each %$obj) {
        if (defined($value)){
            if (($key eq "id" or $key eq "course" or $key eq "courseid"
                or $key eq "assignment" or $key eq "userid" or $key eq
                "instanceid"
                or $key eq "instance" or $key eq "groupingid" or $key eq
                "groupid"
                or $key eq "cmid" or $key eq "contextid" or $key eq "module")) {
                if ($table eq "mdl_role" and $key eq "id"){
                    } else{
                        $value = $prefix . $value;
                } else{
                    $value = JSON::null;
                }
            } else {
                $obj->{key} = $value;
            } return \%$obj;
        } else{
            $value = JSON::null;
        }
    }
}

sub insert{
    my ($table, $obj) = @_;
    if (!checkTableExists($table) == 1) {createTable($table, $obj) }
    checkColumns($table, $obj);
    insertRowToTable($table, $obj);
}

sub insertDirect(){
    my ($table, $obj) = @_;
    insertRowToTable($table, $obj);
}

sub createTable(){
    my ($table, $obj) = @_;
    my $sentence = "CREATE TABLE $table (";
    my $notFirst = 0;
my $addingType = "";
for my $key (keys %$obj) {
    #print "key: $key, value: $obj->{key}\n";
    if ($notFirst == 1) { $sentence = $sentence . ", "; } #print "sentence: $sentence\n";
    if (Scalar::Util::looks_like_number($obj->{key}) == 1) {
        if ($obj->{key} > 2147483646) {
            $addingType = "BIGINT";
        } else {
            $addingType = "BIGINT"; #INT
        }
    } else {
        $addingType = "VARCHAR(255)";
    }
    $sentence = $sentence . $key . " " . $addingType;
    $notFirst = 1;
    $sentence = $sentence . ");\n";
my $pscreate = $db->prepare($sentence);
#print "create: $sentence
";
$pscreate->execute() or die "peta el create";
}

sub checkTableExists() {
    my ($table) = @_;  
    my $pstables = $db->prepare("SHOW TABLES;");
    $pstables->execute() or die "peta el exec checktable\n";
    my @qtables;
    my @tables;
    while (@qtables = $pstables->fetchrow_array()) {
        foreach my $dbtable (@qtables) {
            push @tables, $dbtable;
        }
    }
    my %hashtables = map {$_ => 1}@tables;
    if (exists($hashtables{$table})) { return 1; } else { return 0; }
}

sub checkColumns() {
    my ($table, $obj) = @_;  
    my $pscolumns = $db->prepare("SELECT COLUMN_NAME FROM INFORMATION_SCHEMA.columns WHERE TABLE_SCHEMA = 'DBAgora' AND TABLE_NAME = ?;");
    $pscolumns->bind_param(1, $table);
$pscolumns->execute() or die "peta el exec";
my @qcolumns;
my @columns;
while (@qcolumns = $pscolumns->fetchrow_array()) {
    foreach my $column (@qcolumns){
        push @columns, $column;
    }
}
my %hashcolumns = map {$_ => 1}@columns;
my $addingType = "";
for my $key (keys %$obj) {
    if (!exists($hashcolumns{$key})){
        if (Scalar::Util::looks_like_number($obj->{$key}) == 1){
            if ($obj->{$key} > 2147483646){
                $addingType = "BIGINT";
            }else{
                $addingType = "BIGINT"; #INT
            }
        }else{
            $addingType = "VARCHAR(252)";
        }
    }
    my $psalter = $db->prepare("ALTER TABLE $table ADD $key $addingType;");
    #$print "$psalter\n";
    $psalter->execute() or die "peta el alter";
}
}

sub insertRowToTable(){
    my ($table, $obj) = @_; 
    my $s = "INSERT INTO " . $table . " (";
    my $v = "(";
    my $nofirst = 0;
    for my $key (keys %$obj) {
        if ($nofirst == 1){
            $s = $s . ", ";
            $v = $v . ", ";
        }
    }
    $s = $s . $key;
    $v = $v . "?";
    $nofirst = 1;
} 
    $s = $s . ")";
$v = $v . ")";
$s = $s . " VALUES " . $v . ")";

#print "sentence: $s\n";
my $ps = $db->prepare($s)
  or die "Couldn't prepare statement: " . $db->errstr;
my $paramcount = 1;
for my $key (keys %$obj) {
  $ps->bind_param($paramcount, $obj->{$key});
  $paramcount++;
}
$ps->execute();

print "Total of rows to insert: $count \n";
print "Total of errors: $errors \n";
close(INFO);
Appendix D

Python script for populating a mongoDB

The following script coded in Python takes the file data.json and populates a mongoDB database.

```python
import json

from pymongo import MongoClient

client = MongoClient()  # this will use default port and host

db = client['test-db']  # select the db to use

with open("data.json", "r") as json_f:
    for str_doc in json_f.readlines():
        doc = json.loads(str_doc)
        table = doc.pop("table")  # remove the 'table' key
        db[table].insert(doc)
```
Appendix E

Hive Script for mapping the ontology to Agora

The following script coded in Hive gets the SCHOOLID and builds the knowledge base based on the ontology, for the school 286. Usage example:

$ hive -f createOntoFromAgora.hql -hiveconf SCHOOLID='286'

```sql
1 CREATE DATABASE IF NOT EXISTS ONTO${hiveconf:SCHOOLID};
2 USE ONTO${hiveconf:SCHOOLID};
3
4 CREATE TABLE Subject AS
5 SELECT id as sourcedId, fullname as title FROM
    agora${hiveconf:SCHOOLID}.course;

6 CREATE TABLE Unit AS
7 SELECT id as sourcedid, name as title, section as unitNumber FROM
    agora${hiveconf:SCHOOLID}.course_sections;

8 CREATE TABLE hasUnits AS
9 SELECT c.id as idSubject, cs.id as idUnit FROM
    agora${hiveconf:SCHOOLID}.course c JOIN
    agora${hiveconf:SCHOOLID}.course_sections cs ON c.id =
  cs.course;

10 CREATE TABLE Instructor AS
11 SELECT DISTINCT ra.userid as userid FROM
    agora${hiveconf:SCHOOLID}.role r
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON r.id = ra.roleid
```
WHERE
r.shortname IN ('teacher', 'editingteacher');

CREATE TABLE User AS
SELECT DISTINCT ra.userid as userid, CONCAT('user',ra.userid) as username
FROM agora${hiveconf:SCHOOLID}.role r
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON r.id = ra.roleid
WHERE
r.shortname IN ('teacher', 'editingteacher', 'student');

CREATE TABLE Student AS
SELECT DISTINCT ra.userid as userid
FROM agora${hiveconf:SCHOOLID}.role r
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON r.id = ra.roleid
WHERE
r.shortname IN ('student');

CREATE TABLE Learner AS
SELECT DISTINCT ra.userid as userid, 0as LearnerType, 0as forumAccess, 0 as curiosityRate, 0as deliveryRate, 0as learningObjectAccessed, 0 as numberOfAccesses, 0 as percentageLearningObjectsAccessed
FROM agora${hiveconf:SCHOOLID}.role r
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON r.id = ra.roleid
WHERE
r.shortname IN ('student');

CREATE TABLE Person AS
SELECT DISTINCT ra.userid as sourcedId, CONCAT('person',ra.userid) as name_full
FROM agora${hiveconf:SCHOOLID}.role r
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON r.id = ra.roleid;

CREATE TABLE registeredAs AS
SELECT ra.userid as idUser, ra.userid as idPerson
FROM agora${hiveconf:SCHOOLID}.role r
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON r.id = ra.roleid;

CREATE TABLE CreativeWork AS
SELECT cm.id as id, a.name as name, 0 as dateCreated, a.timemodified as dateModified
FROM agora\${hiveconf:SCHOOLID}.assign a
JOIN agora\${hiveconf:SCHOOLID}.course_modules cm ON a.id = cm.instance
JOIN agora\${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'assign'
UNION ALL
SELECT cm.id as id, fo.name as name, 0 as dateCreated, fo.timemodified as dateModified
FROM agora\${hiveconf:SCHOOLID}.folder fo
JOIN agora\${hiveconf:SCHOOLID}.course_modules cm ON fo.id = cm.instance
JOIN agora\${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'folder'
UNION ALL
SELECT cm.id as id, foro.name as name, 0 as dateCreated, foro.timemodified as dateModified
FROM agora\${hiveconf:SCHOOLID}.forum foro
JOIN agora\${hiveconf:SCHOOLID}.course_modules cm ON foro.id = cm.instance
JOIN agora\${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'forum'
UNION ALL
SELECT cm.id as id, j.name as name, 0 as dateCreated, 0 as dateModified
FROM agora\${hiveconf:SCHOOLID}.jclic j
JOIN agora\${hiveconf:SCHOOLID}.course_modules cm ON j.id = cm.instance
JOIN agora\${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'jclic'
UNION ALL
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated, q.timemodified as dateModified
FROM agora\${hiveconf:SCHOOLID}.quiz q
JOIN agora\${hiveconf:SCHOOLID}.course_modules cm ON q.id = cm.instance
JOIN agora\${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'quiz'
UNION ALL
SELECT cm.id as id, r.name as name, 0 as dateCreated, r.timemodified as dateModified
FROM agora\${hiveconf:SCHOOLID}.resource r
JOIN agora\${hiveconf:SCHOOLID}.course_modules cm ON r.id = cm.instance
JOIN agora\${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'resource'
UNION ALL
SELECT cm.id as id, u.name as name, 0 as dateCreated, u.timemodified as dateModified
FROM agora$.url u
JOIN agora$.course_modules cm ON u.id = cm.instance
JOIN agora$.modules m ON cm.module = m.id
WHERE m.name = 'url'
UNION ALL
SELECT cm.id as id, w.name as name, w.timecreated as dateCreated,
    w.timemodified as dateModified
FROM agora$.wiki w
JOIN agora$.course_modules cm ON w.id = cm.instance
JOIN agora$.modules m ON cm.module = m.id
WHERE m.name = 'wiki'
;
CREATE TABLE LearningObject AS
SELECT cm.id as id, a.name as name, 0 as dateCreated, a.timemodified as dateModified,
    false as available
FROM agora$.assign a
JOIN agora$.course_modules cm ON a.id = cm.instance
JOIN agora$.modules m ON cm.module = m.id
WHERE m.name = 'assign'
UNION ALL
SELECT cm.id as id, fo.name as name, 0 as dateCreated, fo.timemodified as dateModified,
    false as available
FROM agora$.folder fo
JOIN agora$.course_modules cm ON fo.id = cm.instance
JOIN agora$.modules m ON cm.module = m.id
WHERE m.name = 'folder'
UNION ALL
SELECT cm.id as id, foro.name as name, 0 as dateCreated, foro.timemodified as dateModified,
    false as available
FROM agora$.forum foro
JOIN agora$.course_modules cm ON foro.id = cm.instance
JOIN agora$.modules m ON cm.module = m.id
WHERE m.name = 'forum'
UNION ALL
SELECT cm.id as id, j.name as name, 0 as dateCreated, 0 as dateModified,
    false as available
FROM agora$.jclic j
JOIN agora$.course_modules cm ON j.id = cm.instance
JOIN agora$.modules m ON cm.module = m.id
WHERE m.name = 'jclic'
UNION ALL
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated,
FROM agora\{hiveconf:SCHOOLID\}.quiz q
JOIN agora\{hiveconf:SCHOOLID\}.course_modules cm ON q.id = cm.instance
JOIN agora\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'quiz'
UNION ALL
SELECT cm.id as id, r.name as name, 0 as dateCreated, r.timemodified as dateModified, false as available
FROM agora\{hiveconf:SCHOOLID\}.resource r
JOIN agora\{hiveconf:SCHOOLID\}.course_modules cm ON r.id = cm.instance
JOIN agora\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'resource'
UNION ALL
SELECT cm.id as id, u.name as name, 0 as dateCreated, u.timemodified as dateModified, false as available
FROM agora\{hiveconf:SCHOOLID\}.url u
JOIN agora\{hiveconf:SCHOOLID\}.course_modules cm ON u.id = cm.instance
JOIN agora\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'url'
UNION ALL
SELECT cm.id as id, w.name as name, w.timecreated as dateCreated, w.timemodified as dateModified, false as available
FROM agora\{hiveconf:SCHOOLID\}.wiki w
JOIN agora\{hiveconf:SCHOOLID\}.course_modules cm ON w.id = cm.instance
JOIN agora\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'wiki'
;
CREATE TABLE Resource AS
SELECT cm.id as id, fo.name as name, 0 as dateCreated, fo.timemodified as dateModified, false as available
FROM agora\{hiveconf:SCHOOLID\}.folder fo
JOIN agora\{hiveconf:SCHOOLID\}.course_modules cm ON fo.id = cm.instance
JOIN agora\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'folder'
UNION ALL
SELECT cm.id as id, foro.name as name, 0 as dateCreated, foro.timemodified as dateModified, false as available
FROM agora\{hiveconf:SCHOOLID\}.forum foro
JOIN agora\{hiveconf:SCHOOLID\}.course_modules cm ON foro.id = cm.instance
JOIN agora\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'forum'
UNION ALL
```sql
SELECT cm.id as id, r.name as name, 0 as dateCreated, r.timemodified as dateModified, false as available
FROM agora$hiveconf:SCHOOLID}.resource r
JOIN agora$hiveconf:SCHOOLID}.course_modules cm ON r.id = cm.instance
JOIN agora$hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'resource'
UNION ALL
SELECT cm.id as id, u.name as name, 0 as dateCreated, u.timemodified as dateModified, false as available
FROM agora$hiveconf:SCHOOLID}.url u
JOIN agora$hiveconf:SCHOOLID}.course_modules cm ON u.id = cm.instance
JOIN agora$hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'url'
UNION ALL
SELECT cm.id as id, w.name as name, w.timecreated as dateCreated, w.timemodified as dateModified, false as available
FROM agora$hiveconf:SCHOOLID}.wiki w
JOIN agora$hiveconf:SCHOOLID}.course_modules cm ON w.id = cm.instance
JOIN agora$hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'wiki'
;
CREATE TABLE Dictionary AS
SELECT cm.id as id, w.name as name, w.timecreated as dateCreated, w.timemodified as dateModified, false as available
FROM agora$hiveconf:SCHOOLID}.wiki w
JOIN agora$hiveconf:SCHOOLID}.course_modules cm ON w.id = cm.instance
JOIN agora$hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'wiki'
;
CREATE TABLE Wiki AS
SELECT cm.id as id, w.name as name, w.timecreated as dateCreated, w.timemodified as dateModified, false as available
FROM agora$hiveconf:SCHOOLID}.wiki w
JOIN agora$hiveconf:SCHOOLID}.course_modules cm ON w.id = cm.instance
JOIN agora$hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'wiki'
;
CREATE TABLE Forum AS
SELECT cm.id as id, foro.name as name, 0 as dateCreated, foro.timemodified as dateModified, false as available, foro.name as topic
```
FROM agora$\{hiveconf:SCHOOLID\}.forum foro
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON foro.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'forum';

CREATE TABLE Activity AS
SELECT cm.id as id, a.name as name, 0 as dateCreated, a.timemodified as dateModified, false as available, 0 as dateToShow, 0 as dateToSubmit
FROM agora$\{hiveconf:SCHOOLID\}.assign a
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON a.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'assign'
UNION ALL
SELECT cm.id as id, j.name as name, 0 as dateCreated, 0 as dateModified, false as available, j.timeavailable as dateToStartOn, 0 as dateToActivate, 0 as dateToShow, j.timedue as dateToSubmit
FROM agora$\{hiveconf:SCHOOLID\}.jclic j
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON j.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'jclic'
UNION ALL
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated, q.timemodified as dateModified, false as available, q.timeopen as dateToShow, q.timeclose as dateToSubmit
FROM agora$\{hiveconf:SCHOOLID\}.quiz q
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON q.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'quiz';

CREATE TABLE Exercise AS
SELECT cm.id as id, a.name as name, 0 as dateCreated, a.timemodified as dateModified, false as available, 0 as dateToShow, 0 as dateToSubmit
FROM agora$\{hiveconf:SCHOOLID\}.assign a
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON a.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'assign'
UNION ALL
SELECT cm.id as id, j.name as name, 0 as dateCreated, 0 as dateModified, false as available, j.timeavailable as dateToStartOn, 0 as dateToActivate, 0 as dateToShow, j.timedue as dateToSubmit
FROM agora$\{hiveconf:SCHOOLID\}.jclic j
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON j.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'jclic'
UNION ALL
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated, q.timemodified as dateModified, false as available, q.timeopen as dateToShow, q.timeclose as dateToSubmit
FROM agora$\{hiveconf:SCHOOLID\}.quiz q
JOIN agora$\{hiveconf:SCHOOLID\}.course_modules cm ON q.id = cm.instance
JOIN agora$\{hiveconf:SCHOOLID\}.modules m ON cm.module = m.id
WHERE m.name = 'quiz';
false as available, j.timeavailable as dateToStartOn, 0as dateToActivate, 0as dateToShow, j.timedue as dateToSubmit
FROM agora$[hiveconf:SCHOOLID].jclic j
JOIN agora$[hiveconf:SCHOOLID].course_modules cm ON j.id = cm.instance
JOIN agora$[hiveconf:SCHOOLID].modules m ON cm.module = m.id
WHERE m.name = 'jclic'
UNION ALL
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated,
    q.timemodified as dateModified, false as available, q.timeopen as
dateToStart
FROM agora$[hiveconf:SCHOOLID].quiz q
JOIN agora$[hiveconf:SCHOOLID].course_modules cm ON q.id = cm.instance
JOIN agora$[hiveconf:SCHOOLID].modules m ON cm.module = m.id
WHERE m.name = 'quiz'
;
CREATE TABLE Assignment AS
SELECT cm.id as id, a.name as name, 0as dateCreated, a.timemodified as
dateModified, false as available, 0as dateToStartOn, 0as dateToActivate, 0as
dateToShow, 0as dateToSubmit
FROM agora$[hiveconf:SCHOOLID].assign a
JOIN agora$[hiveconf:SCHOOLID].course_modules cm ON a.id = cm.instance
JOIN agora$[hiveconf:SCHOOLID].modules m ON cm.module = m.id
WHERE m.name = 'assign';
CREATE TABLE Test AS
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated,
    q.timemodified as dateModified, false as available, q.timeopen as
dateToStart
FROM agora$[hiveconf:SCHOOLID].quiz q
JOIN agora$[hiveconf:SCHOOLID].course_modules cm ON q.id = cm.instance
JOIN agora$[hiveconf:SCHOOLID].modules m ON cm.module = m.id
WHERE m.name = 'quiz';
CREATE TABLE Quiz AS
SELECT cm.id as id, q.name as name, q.timecreated as dateCreated,
    q.timemodified as dateModified, false as available, q.timeopen as
dateToStart
FROM agora$[hiveconf:SCHOOLID].quiz q
JOIN agora$[hiveconf:SCHOOLID].course_modules cm ON q.id = cm.instance
JOIN agora$[hiveconf:SCHOOLID].modules m ON cm.module = m.id
JOIN agora${hiveconf:SCHOOLID}.modules m ON cm.module = m.id
WHERE m.name = 'quiz';

CREATE TABLE UserInteraction AS
SELECT
  lo.userid as userid,
  from_unixtime(lo.timecreated) as datetime,
  lo.contextinstanceid as learningObject,
  lo.id as sourcedId,
  from_unixtime(lo.timecreated) as startDate,
  from_unixtime(lo.timecreated) as endDate,
  CASE
    WHEN lo.action = 'viewed' AND (lo.component = 'mod_assign' AND
      lo.eventname LIKE '%submission_form%') THEN 'initialized'
    WHEN lo.action = 'viewed' THEN 'opened'
    WHEN lo.action = 'uploaded' THEN 'attached'
    WHEN (lo.action = 'updated' OR lo.action = 'created') AND lo.component
      = 'assignsubmission_file' THEN 'delivered'
    WHEN lo.action = 'submitted' THEN 'submitted'
    WHEN lo.action = 'created' AND lo.eventname LIKE '%comment_created%'
      THEN 'commented'
  ELSE 'interacted'
END as action,
  CONCAT(lo.eventname,'.',lo.objectid,'.',lo.objecttable) as info,
  (lo.timecreated+1 - lo.timecreated) as activityTime,
  0 as timeUntilAccess
FROM
  agora${hiveconf:SCHOOLID}.logstore_standard_log lo
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON lo.userid =
  ra.userid
JOIN agora${hiveconf:SCHOOLID}.role ro ON ra.roleid = ro.id
WHERE
  lo.contextlevel = 70
  AND ro.shortname = 'student';

CREATE TABLE Event AS
SELECT
  lo.id as sourcedId,
  from_unixtime(lo.timecreated) as startDate,
  from_unixtime(lo.timecreated) as endDate
FROM
  agora${hiveconf:SCHOOLID}.logstore_standard_log lo
JOIN agora${hiveconf:SCHOOLID}.role_assignments ra ON lo.userid =
  ra.userid
JOIN agora${hiveconf:SCHOOLID}.role ro ON ra.roleid = ro.id
WHERE
  lo.contextlevel = 70
  AND ro.shortname = 'student';
JOIN agora$hiveconf:SCHOOLID}.role_assignments ra ON lo.userid = ra.userid
JOIN agora$hiveconf:SCHOOLID}.role ro ON ra.roleid = ro.id
WHERE lo.contextlevel = 70
AND ro.shortname = 'student'

;