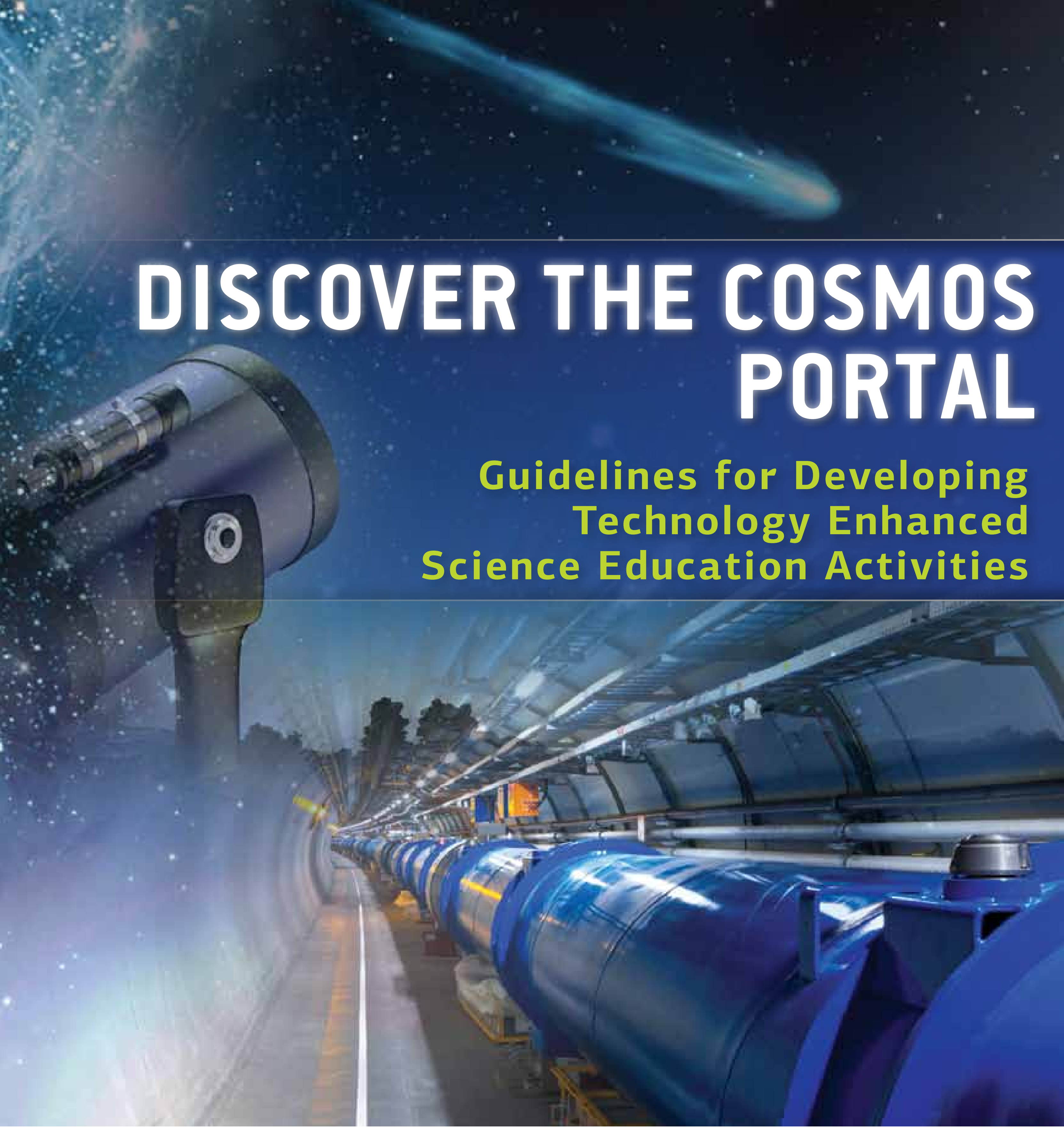
DISCOVER THE COSMOS PORTAL

Guidelines for Developing Technology Enhanced Science Education Activities



http://portal.discoverthecosmos.eu

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DISCOVER THE COSMOS PORTAL

Guidelines for Developing Technology Enhanced Science Education Activities

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Contents

List of figures

List of tables

1. Introduction

1.1 Scope

The scope of this document is to (a) present the Discover the Cosmos LOM Science Education Profile, adopted from the COSMOS IEEE LOM Science Education Application Profile, that it is used to characterize with educational metadata the Science Education Content and Learning Missions, (b) describe the functionalities and the technical specifications of the Discover the Cosmos Metadata Authoring and Management Toolkit (DtC-LOM) and (c) introduce the teachers to inquiry based learning activities.

The aim of the Discover the Cosmos technical infrastructure is to support all stages of the chain: creation, publication, discovery, acquisition, access and use of Science Educational Content. The Discover the Cosmos technical approach adopts the current state of the art learning technologies and consists of the following components:

The Discover the Cosmos–Learning Object Metadata (LOM) Toolkit: The Discover the Cosmos-Learning Object Metadata web-based toolkit will allow Science Education Content Suppliers to characterize their resources and Science Education Learning Missions Suppliers to characterize the Learning Missions they build. This web-based toolkit allows authoring and managing of metadata for the Discover the Cosmos Educational Content and Learning Missions.

The Discover the Cosmos Authoring Engine for Learning Missions: The Discover the Cosmos Authoring Engine for Learning Missions will enable the definition of Learning Missions implementing the Generic Technology-Enhanced educational scenario Templates. The Discover the Cosmos Educational Scenarios will be described in an interoperable (machine readable) formal based on the current state-of-the-art learning technologies, and more precisely the IMS Learning Design specification, so as to achieve platform independent delivery of Learning Missions. The IMS Learning Design specification defines an XML-based schema, which specifies a uniform and flexible abstraction for representing the structure of an Educational Scenario.

The DtC-LOM is conformant with the Discover the Cosmos IEEE LOM Science Education Application profile. The DtC-LOM is intended to be used by teachers to characterize with metadata their Science Education Resources, in order to enable Science Education e-Learning Activities suppliers to search, find and reuse Science Education Resources in order to build Science Education e-Learning Activities. Moreover, the introduced Inquiry Based Teaching template guides teachers to the designing of meaningful learning activities according to standard format.

1.2 Rationale and Methodology

Science education is a top priority for European policy makers (Rocard et al., 2007). Over the past years the development of technological tools such as augmented reality, virtual reality, portable devices, wearable computers, simulations and computer modelling of physical phenomena in science classrooms, has allowed the enhancement and enrichment of their current curriculum. A large amount of digital science education content already exists in the form of science museum collections, digital repositories and libraries. This large amount of digital science content has the potential to support technology – enhanced science education. Typically, educational resources in technology-enhanced learning are organized as **"learning objects"** (LOs) (Wiley, 2002; McGreal, 2004). Over the last decade LOs have gained a lot of interest as the basis of a new type of computer-based instruction in which the instructional content is created from reusable components.

On the other hand, the creation of quality educational resources is a costly process, especially in science education (Zimmermann et al., 2007). Hence, reuse of high quality learning materials has become a very important research topic for a variety of people, organizations etc as it can lead to an important reduction of development cost and time; while at the same time can improve its quality.

However, science education teachers are lacking the time to investigate the potential educational added-value of the huge amount of digital resources typically returned through web search engines (Mason, 2006). An important factor, in order to make search and retrieval of science educational content more efficient is the quality and quantity of educational metadata associated with these resources. In general the commonly accepted way to describe educational resources is the IEEE Learning Object Metadata (LOM) Standard (IEEE LOM, 2002). Nevertheless, it is beyond the scope of IEEE LOM to directly support the description of science curriculum related characteristics of Science Education Resources.

Therefore, within the context of the Discover the Cosmos project an Education Application Profile has been proposed. The DtC LOM Science Education Application Profile was developed by applying the guidelines for building application profiles in e- Learning provided by the COSMOS project. Moreover, based on the characteristics of high energy physics curriculum, we have used the controlled vocabularies that can indicate possible extensions to the IEEE LOM Standard concerning science curriculum properties. These vocabularies have been also derived from the COSMOS project for the categorization of Science Education Resources and have been further extended by producing a new vocabulary based on high energy physics.

To this end the document is structured as follows: In section 2, we provide an overview of the basic concepts used in this document, namely Learning Objects, Educational Metadata and Application Profiles. In section 3, we provide a general description of the Discover the Cosmos Learning Objects Metadata Authoring Toolkit (DtC-LOM). Moreover, we describe the DtC-LOM Authoring Process, and we present the DtC-LOM interface functionalities and features. At the end, we describe the metadata elements that constitute the Discover the Cosmos LOM Science Education Application Profile in a form of a table. In section 4, Inquiry Based Teaching (IBT) is presented in the form of (a) a flow of learning activities and (b) tables where the activity designing process is explained step by step.

2. Basic Concepts

2.1 Learning Objects

Learning Objects are presented in literature as a new way of thinking about learning content that are developed to support technology-enhanced learning processes (Polsani, 2003). Learning objects were defined by the IEEE Learning Technology Standardization Committee (LTSC) as “any entity, digital or non-digital, that can be reused for learning, teaching or training” (IEEE LOM, 2002). In general, any digital resource that can be reused to support learning (Wiley, 2002), can be considered as learning object.

Learning objects include, but are not limited to, simulations, animations, tutorials, diagrams, audio and video clips, quizzes and assessments. The main difference between a learning object and an information object is that the learning object is designed to support a concrete educational goal: that is, it is associated with one or more learning objectives.

2.2 Educational Metadata

Metadata are generally defined as data about an information resource, or simply data about data (Berners-Lee, 1997). They describe the different characteristics and attributes of an information source, i.e. Title, Author, Date and Subject.

A **metadata model** is a structured description about the characteristics and properties of an information resource, and allows the creation of catalogues and indexes for information resources, as well as, searching information resources on the basis of these characteristics. The metadata specification used widely for the description of digital information resources is Dublin Core[1] (DC) (Greenberg, 2001).

In the case of learning objects, generic metadata models for digital resources (such as the Dublin Core model) are not sufficient, as they do not include information about the educational characteristics of an object. Therefore, specialized models that give emphasis on the **educational metadata** of digital resources have been developed. Educational metadata represent the educational characteristics of a learning object, such as the target groups it involves, or the thematic area it concerns. The educational metadata specification used widely for the description of learning objects is the IEEE Learning Object Metadata (LOM) (IEEE LOM, 2002).

Typically, educational resources tagged with metadata are stored in web-based repositories referred to as Learning Object Metadata Repositories. **Learning Object Metadata Repositories** store learning object metadata records and offer facilities for searching, retrieving and sharing educational resources in the form of learning objects. Learning object metadata repositories are being developed worldwide in order to collect descriptions of learning objects, and facilitate interested users (such as educators, students and content providers) in locating and accessing them. Popular learning objects metadata repositories include MERLOT[2] in USA and ARIADNE[3] in Europe.

1 http://dublincore.org
2 http://www.merlot.org
3 http://www.ariadne-eu.org

2.3 Application Profiles

An **Application Profile** is an assemblage of metadata elements selected from one or more metadata schemas and combined in a compound schema (Duval et al., 2002). The purpose of an application profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas. An application profile is typically developed for a particular application with a particular constituency. Such a community may be large (for instance: the European Academic context) or small (for instance: a small enterprise in a particular domain) (Duval et al., 2006).

According to CEN/ISSS Learning Technologies Workshop (CEN/ISSS-LTW) (Duval et al., 2006) the principle motivation for defining an application profile, refers to the ability of a system to process metadata instances produced by a third party system. The general underlying principle is that, where a new application profile is being produced, it should either be based on one or more standards or on one or more existing application profiles of those standards and it should not compromise interoperability by breaking conformance with the existing standards. To this end, CEN/ISSS-LTW provides guidance on how to build application profiles for e-learning[4].

A full description of the Discover the Cosmos LOM Science Education Application Profile is given in the form of a tables at the end of section 3.

4 ftp://ftp.cenorm.be/PUBLIC/CWAs/e-Europe/WS-LT/cwa15555-00-2006-Jun.pdf

3. Discover the Cosmos Learning Objects Metadata Authoring Toolkit (DtC-LOM)

This section presents the functionalities of the Discover the Cosmos Learning Objects Metadata, a web-based authoring toolkit which is conformant with the Discover the Cosmos LOM Science Education Profile described below.

3.1General Description and Functionalities

Discover the Cosmos Learning Objects Metadata (DtC-LOM) is a web-based tool that facilitates authoring and management of educational and science education related metadata following the Discover the Cosmos LOM Science Education Application Profile. The main functionalities of DtC-LOM include:

- Educational metadata authoring of learning objects following the Discover the Cosmos LOM Science Education Profile, which is conformant with the COSMOS IEEE LOM Science Education Application Profile, through the use of a web- based authoring tool.
- Educational metadata records management and creation of Learning Objects Local Metadata Repository.
- Export of individual educational metadata records as XML files.

In order to start the DtC-LOM you have to visit the Discover the Cosmos portal (*http://portal.discoverthecosmos.eu*).

In the Discover the Cosmos repository tab you click the ‘Upload Educational Content’ under the ‘Share your Content.’ The web-based DtC-LOM tool appears with the link: *http://portal.discoverthecosmos.eu/online-atlas-lom/?m=wizard*. (See figures 3.1, 3.2, and 3.3).

Figure 3.1: *The home page of the Discover the Cosmos Education and Outreach Portal which describes the aims of the portal as well as it explains the types of educational materials that are included.*

Figure 3.2: *The Discover the Cosmos repository where the user can either search for educational material or upload his/her own material either in the form of educational content (photos, videos, animations etc) or in the form of learning missions (structured lesson plans)*

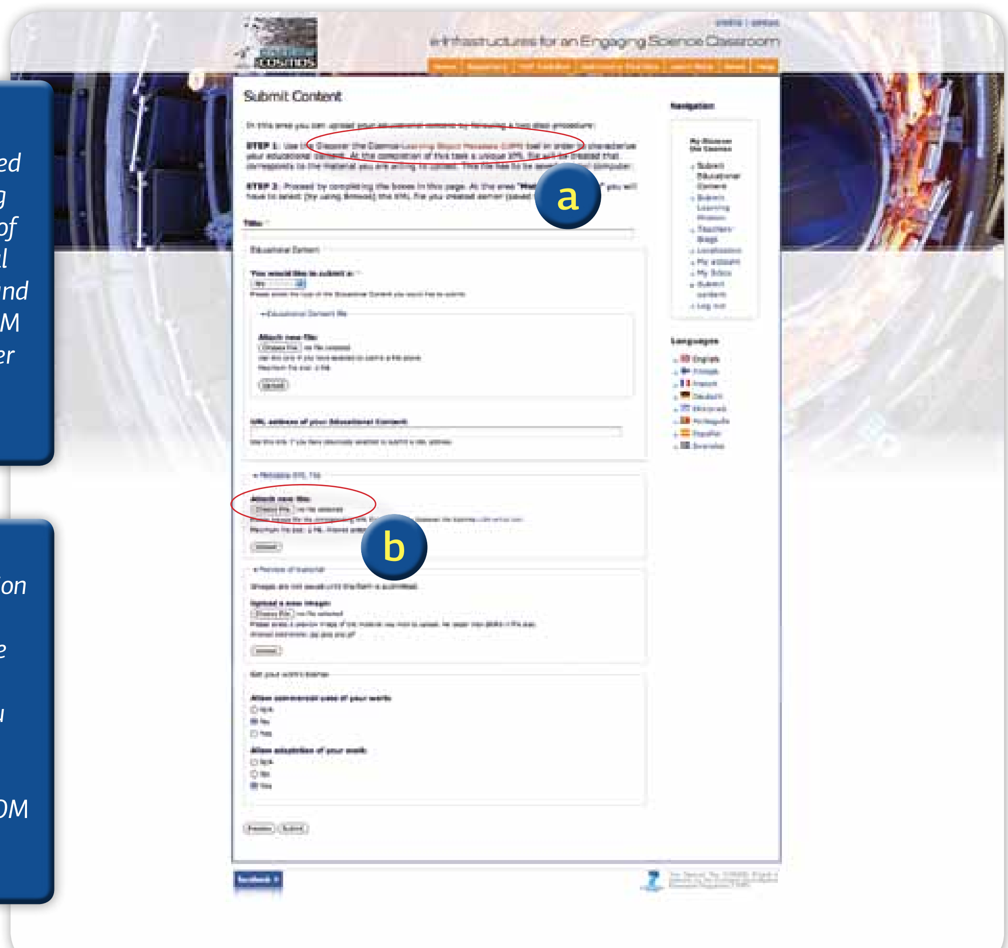


Figure 3.3a: *Link to the DtC-LOM web-based application for creating metadata. In the area of 'submitting educational content' the user can find the link for the DtC-LOM web application in order to characterise educational content.*

Figure 3.3b: *Submission of educational content after the creation of the XML file. At the area 'Metadata XML file' you will have to select the XML file you created earlier using the DtC-LOM web-based application*

You click on the link, http://www.learningwithatlas-portal.eu/online-atlas- lom/?m=wizard and you will navigate to the DtC-LOM web-based application and the first screen will appear. After the characterization of the learning object, users can proceed on the submission of their educational content. At the area 'Metadata XML file' users will have to select the XML file that was previously created in the DtC-LOM tool. Users can submit either a file or a URL address, the XML file created using the DtC-LOM tool as well as an image as a preview of the material users wish to upload (see figure 3.3). Once users have provided the necessary material (i.e. title, file or URL, Metadata XML file and image) they need to click the 'upload button' to submit their educational content (see figure 3.3).

3.2 DtC-LOM Authoring Proces

Figure 3.4 depicts the Learning Object Metadata authoring process with the use of the DtC-LOM web tool.

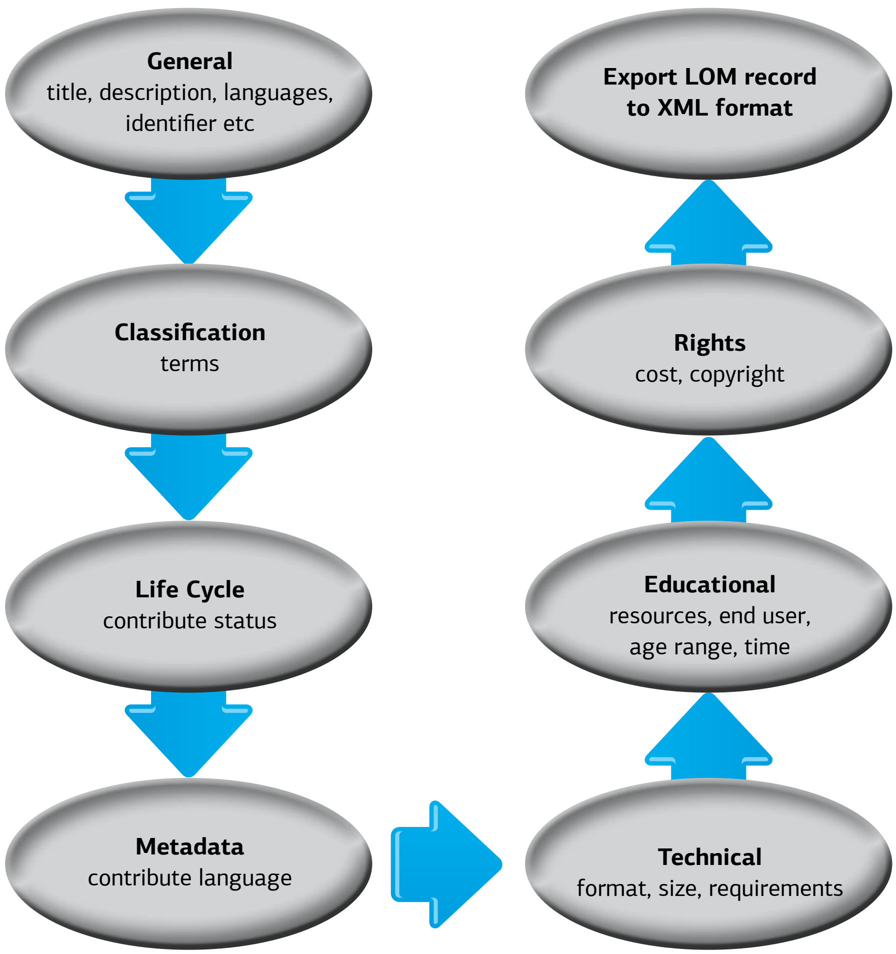


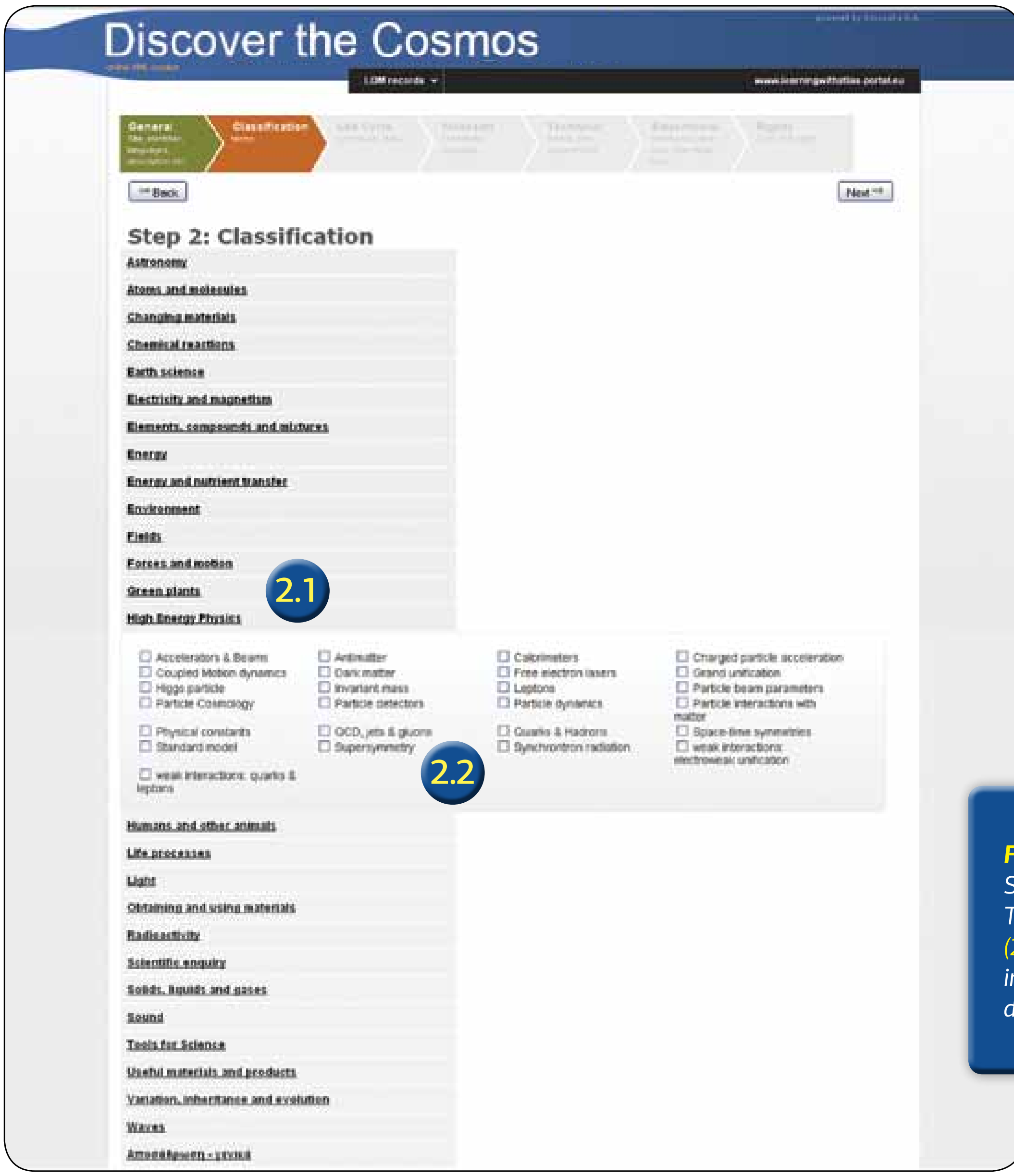
Figure 3.4: *Learning Object Metadata Authoring Process*

The Learning Object Metadata authoring process consists of eight (8) basic steps.
All steps are depicted in Figure 3.4 and presented analytically in the pages to follow.
Moreover, the elements of each step are numbered and described in detail in section 3.3 (see page 15)

Step 1-General: During this step the user gives the title of the learning object, the textual description of the content in terms of the particular learning object. Furthermore, the user selects the primary language or languages used within the learning object to communicate to the intended user (see figure 3.5)

Figure 3.5: *Step 1-General:*
The user inserts the title (1.1), the description (1.2) and the languages (1.3) which compose the textual information of the learning object in terms of communicating with the user. The user also provides appropriate keywords (1.4) separated with comma for describing the topic of the learning object, the identifier (1.5) for identifying the learning object, the structure (1.6) for underlying the organizational structure and the aggregation level (1.7) in terms of the functional granularity of the learning object. .

Then the user provides keywords in the form of text or phrase for describing the topic of the learning object as well as the identification label which is a globally unique label that identifies the learning object. Then the user selects from a drop-down list the structure of the learning objects which consists of atomic (an object that is invisible), collection (a set of objects with no specified relationship between them), networked (a set of objects with relationships that are unspecified), hierarchical (a set of objects whose relationship can be represented by a tree structure) and linear (a set of objects that are fully ordered, e.g. A set of objects that are connected by 'previous' and 'next' relationships. Finally, the user selects the aggregation level. Aggregation level is the functional granularity of the learning object. 1 is the smallest level, e.g. atlas images, worksheets etc, and 2 a collection of learning objects e.g. a learning mission (see Figure 3.5).



Step 2 - Classification: During this step the user indicates the terms that characterize the learning object within a particular classification system. In particular, there is a wide range of subject areas for the user to select and each one of them is consisted of different sub-categories (see Figure 3.6). The user can select different subject areas simultaneously as well as indicating the desired sub-topic(s).

Figure 3.6:
Step 2-Classification:
The user indicates the subject areas (2.1) that characterise the learning object as well as indicating the desired sub-topics (2.2).

Step 3 - Life Cycle: During this step, the user gives the name of the authors of the learning object separated with comma, the date of the contribution, the names of the publishers of the learning object, the date of the contribution and the completion status or condition of the learning object in terms of a draft, final, revised and unavailable (see Figure 3.7)

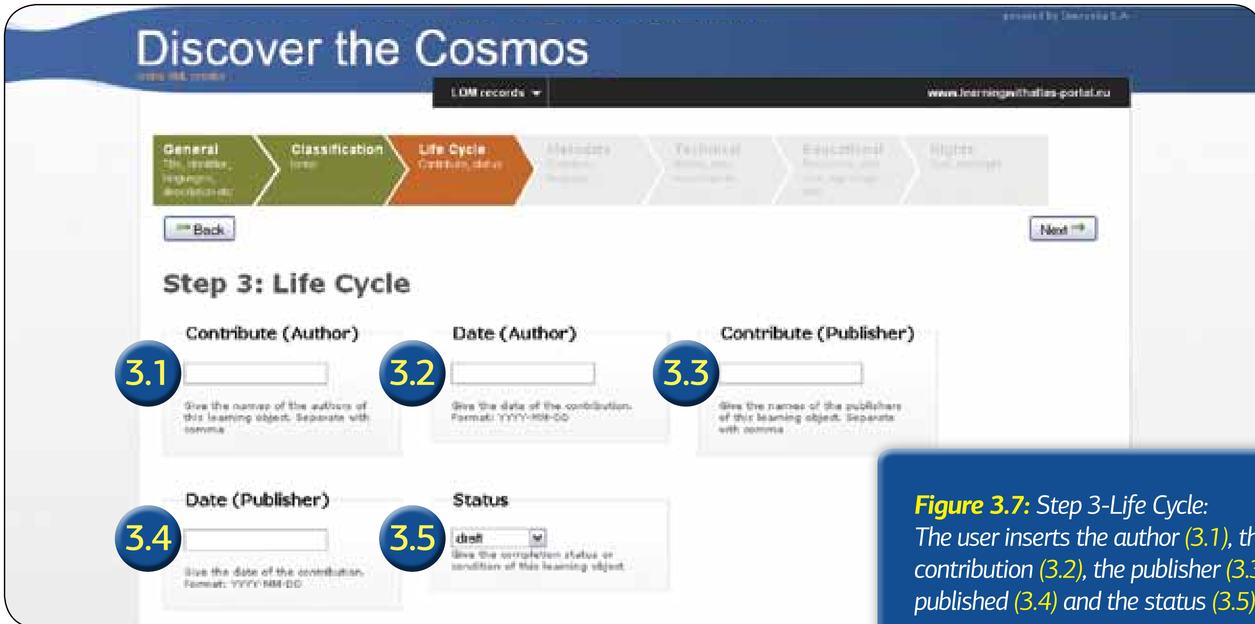


Figure 3.7: Step 3-Life Cycle: The user inserts the author (3.1), the date of contribution (3.2), the publisher (3.3), the date published (3.4) and the status (3.5)

Step 4 – Metadata: During this step the user inserts information about the metadata such as the name of the creator; the date of the contribution; the metadata language; the name of the validator as well as the date of validation (see Figure 3.8)

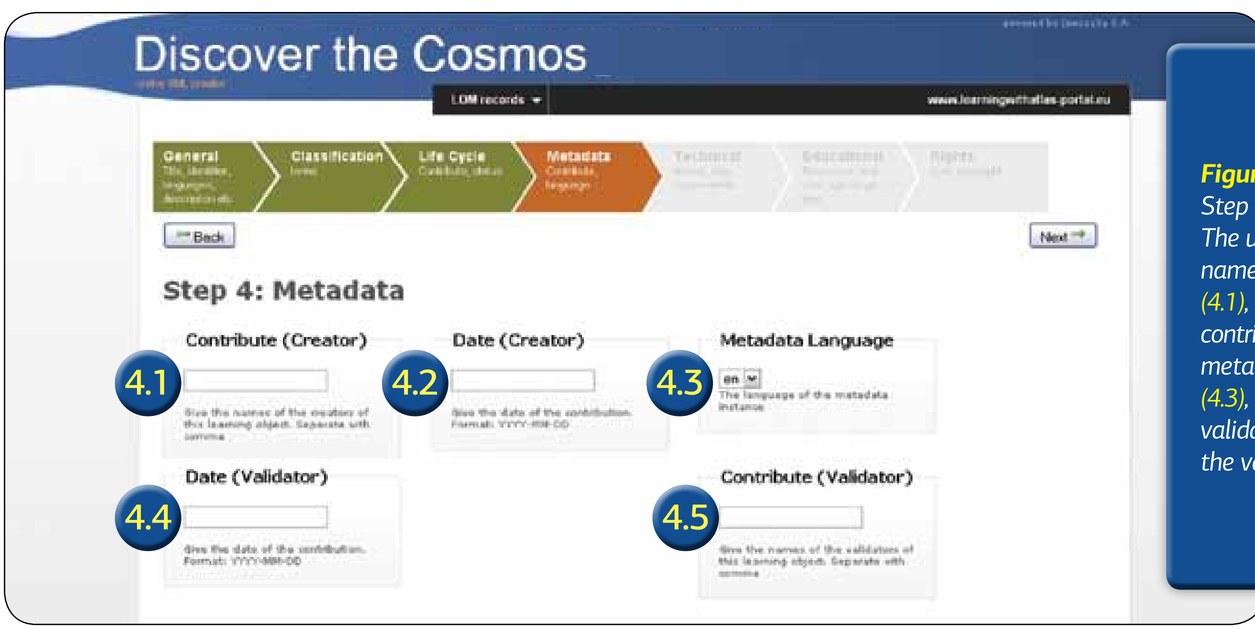


Figure 3.8: Step 4-Metadata: The user inserts the name of the creator (4.1), the date of contribution (4.2), the metadata language (4.3), the date of validation (4.4) and the validator (4.5).

Step 5 – Technical: In this step the user gives the technical requirements necessary for using the learning object. Insert the format required using the learning object described as the technical datatype of each component of the learning object, the browsers (insert the minimum and the maximum possible version of the required browser to use the learning object) the operating systems (insert the minimum and the maximum possible version of the required operating system to use the learning object) and the size of the data element using the given list (see Figure 3.9).

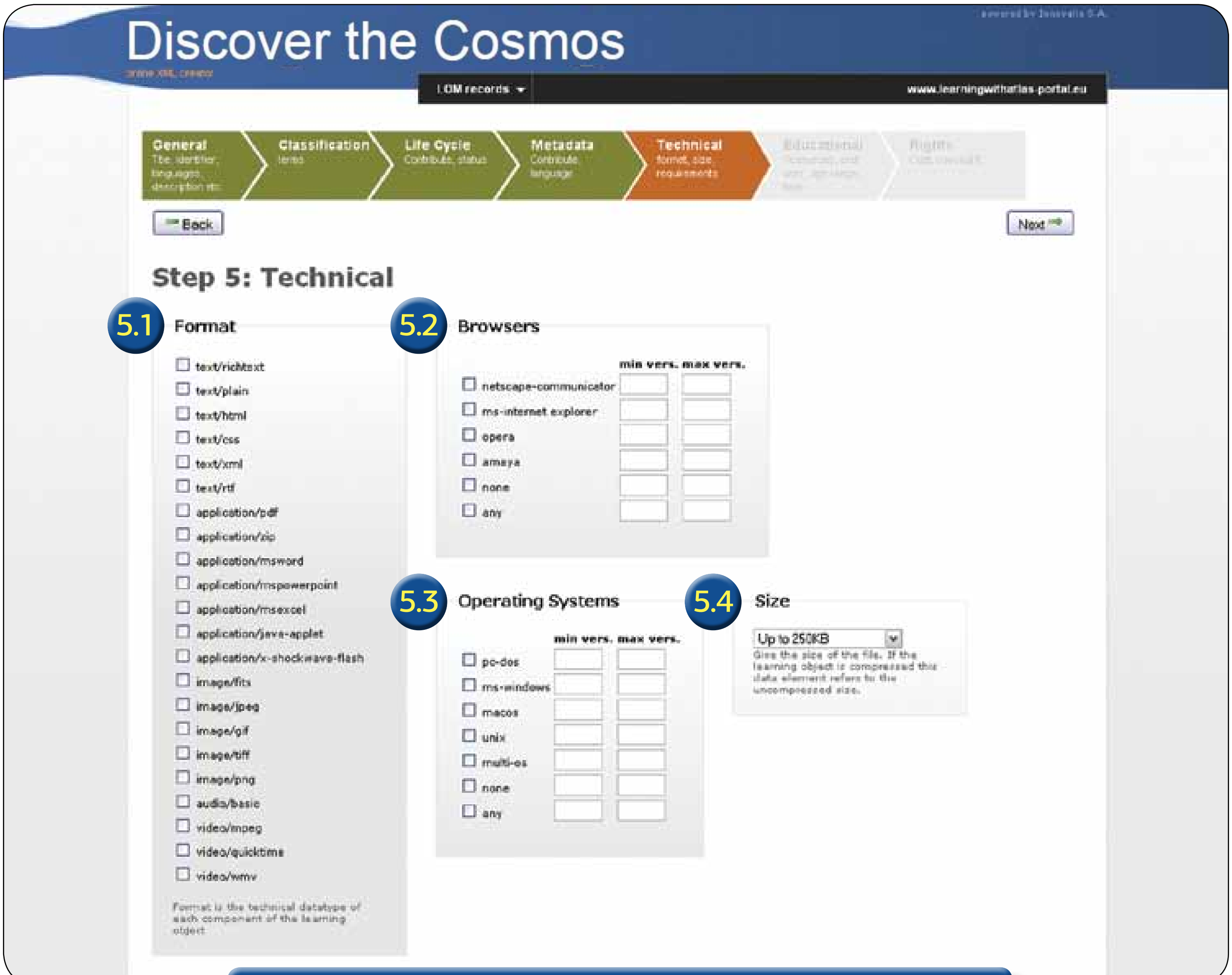


__Figure 3.9:__ Step 5-Technical:
The user inserts the format of the uploaded educational material (5.1), the browser (5.2) required for someone to view this material, the operating system (5.3) needed and the appromate size (5.4) of the learning object.

Step 6-Educational: In this step the user gives the technical requirements necessary for using the learning object such as learning resource type (specific kind of learning object) interactivity type (active: learning by doing, expositive: passive learning, mixed blends: active and expositive learning), interactivity level (the degree of interactivity characterizing the learning object), difficulty (how hard is to work with or through this learning object for the typical target audience), typical learning time (the time that is needed for the learner to work with the learning object), intended user role (principal users for which this learning object is designed), context (the principal environment within which the learning and use of this learning object is intended to take place), typical age range (give the age of the typical intended user) (see Figure 3.10)

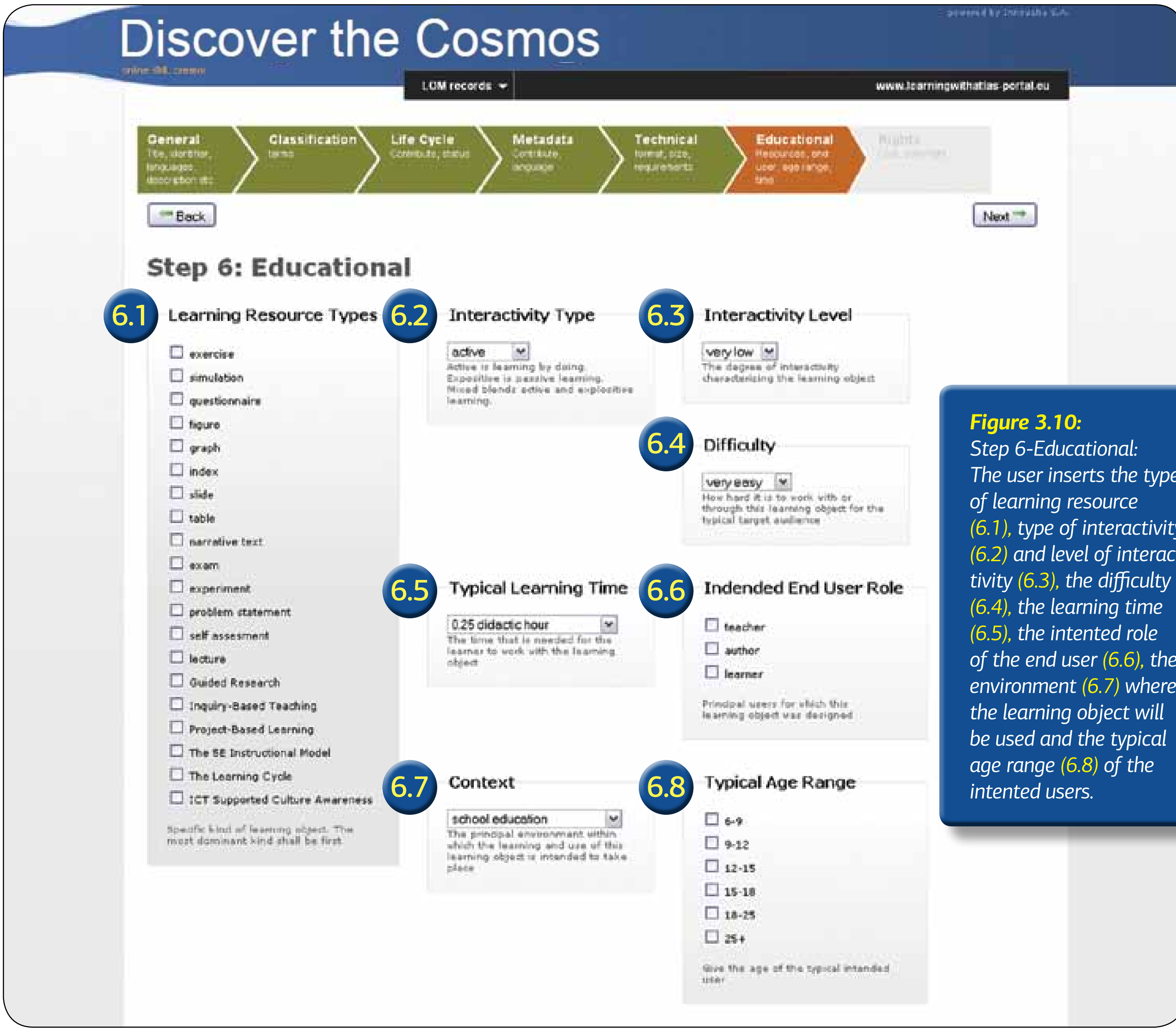


Figure 3.10: *Step 6-Educational: The user inserts the type of learning resource (6.1), type of interactivity (6.2) and level of interactivity (6.3), the difficulty (6.4), the learning time (6.5), the intented role of the end user (6.6), the environment (6.7) where the learning object will be used and the typical age range (6.8) of the intented users.*

Step 7-Rights: During this step the user selects the cost (whether use of this learning object requires cost) and copyright (whether copyright or other restrictions apply to the use of the learning object) (see Figure 3.11)

Figure 3.11:
Step 7-Rights:
The user inserts the rights requirements: Cost (7.1) and Copyright (7.2).

Step 8-Export LOM record to XML Format: When all steps are completed, the user is prompted to export an XML file which can be viewed through a browser. More specifically, it offers the exporting of a selected learning object's metadata record as a single XML file that conforms with the IEEE LOM standard (see Figure 3.12).

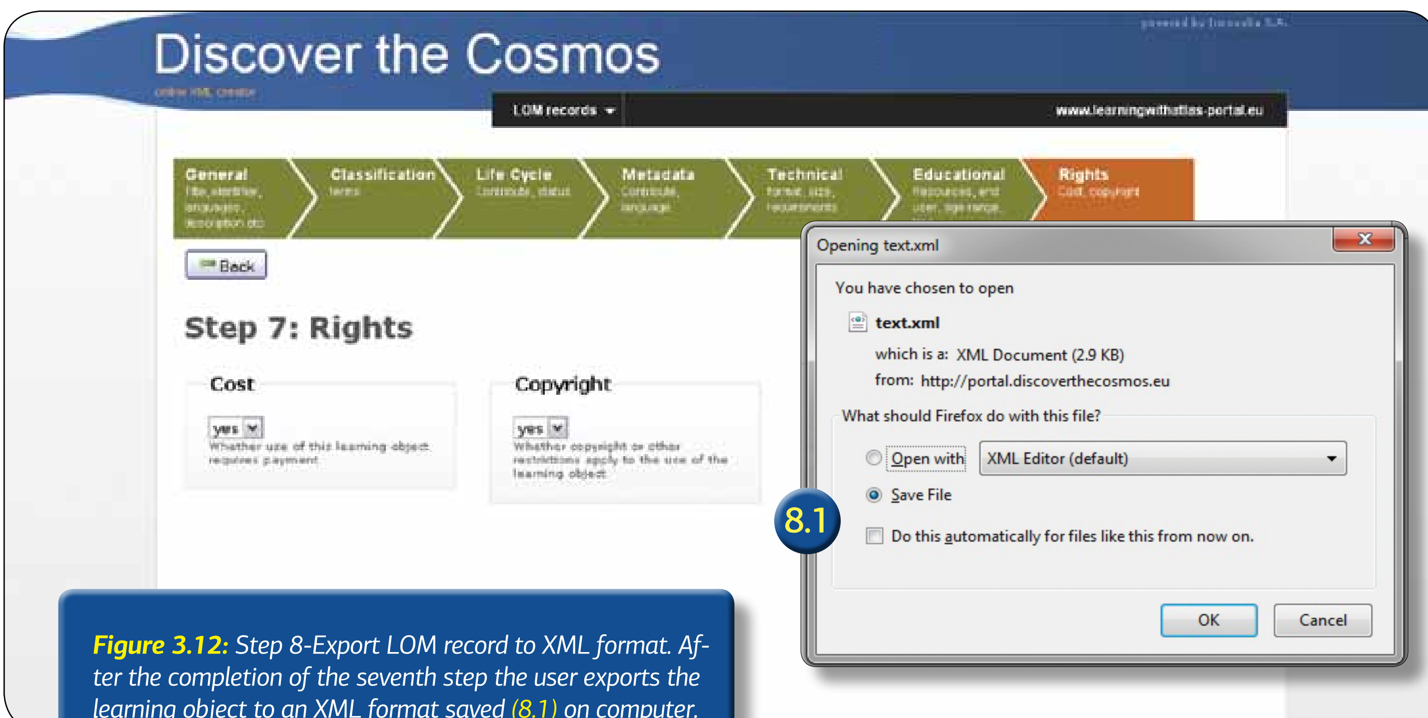


Figure 3.12: *Step 8-Export LOM record to XML format. After the completion of the seventh step the user exports the learning object to an XML format saved (8.1) on computer.*

3.3 Description of Discover the Cosmos LOM Science Education Application Profile.

This section describes in detail in a form of tables the DtC LOM Science Education Application Profile.

The metadata elements that have been used for the development of the DtC LOM Science Education Application Profile are based on the COSMOS IEEE LOM Science Education Application Profile. The last column of the table includes a Vocabulary for several metadata elements. The vocabulary of the element 2.2 Classification/Subject area/Subtopics has derived from the classification that the COSMOS project Portal was using, for categorizing Science Education Resources.

***Table 3.1:** Step 1-General: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
1	General	This category groups the general information that describes this learning object as a whole	
1.1	Title	Name given to this learning object.	Example: Momentum Conservation
1.2	Description	A textual description of the content of this learning object.	Example: Two particles collide and the momentum in the plane perpendicular to the axis of collision is conserved
1.3	Languages	The primary human language or languages used within this learning object to communicate to the intended user.	**en:** English Language **de:** German Language **fi:** Finnish Language **el:** Greek Language **sv:** Swedish Language **fr:** French Language
1.4	Keywords	A keyword or phrase describing the topic of this learning object.	Example: momentum, collisions
1.5	Identification	A globally unique label that identifies this learning object	
1.5.1	Catalog	The name or designator of the identification or cataloging scheme for this entry	ISBN ISSN URI URL
1.5.2	Entry	The value of the identifier within the identification or cataloging scheme that designates or identifies this earning object. A namespace specific string.	
1.6	Structure	Underlying organizational structure of this learning object.	**Atomic:** an object that is indivisible **Collection:** a set of objects with no specified relationship between them. **Networked:** a set of objects with relationships that are unspecified. **Hierarchical:** a set of objects whose relationships can be represented by a tree structure. **Linear:** a set of objects that are fully ordered. Example: A set of objects that are connected by "previous" and "next" relationships.
1.7	Aggregation Level	The functional granularity of this learning object	**1:** the smallest level of aggregation, e.g., ATLAS images, worksheets, etc. **2:** a collection of learning objects, e.g., a learning activity

***Table 3.2:** Step 2-Classification: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
2	Classification	This category describes where this learning object falls within a particular classification system.	
2.1	Subject area	A subject area in a specific classification system.	Science
2.2	Subtopics	The name of a topic within the subject area.	Science

***Table 3.3:** Step 3-Life Cycle: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
3	Life Cycle	This category describes the history and current state of this learning object and those entities that have affected this learning object during its evolution.	
3.1	Contribute (Author)	Those entities (i.e., people, organizations) that have contributed to the state of this learning object during its life cycle (e.g., creation, edits, publication).	
3.2	Date (Author)	The date of the contribution.	Example: 2009-12-25
3.3	Contribute (Publisher)	The names of the publishers (separated by commas if more than one) of the learning object	
3.4	Date (Publisher)	The date of publication on the portal	Example: 2009-12-25
3.5	Status	The completion status or condition of this learning object.	draft final revised unavailable

Table 3.4: *Step 4-Metadata: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
4	Metadata	This category describes this metadata record itself (rather than the learning object that this record describes).	
4.1	Contribute (Creator)	Those entities (i.e., people or organizations) that have affected the state of this metadata instance during its life cycle (e.g., creation).	
4.2	Date (Creator)	The date of the contribution of the creator	Example: 2009-12-25
4.3	Language	Language of this metadata instance	**en:** English Language **de:** German Language **fi:** Finnish Language **el:** Greek Language **sv:** Swedish Language **Fr:** French Language
4.4	Date (Validator)	The date of contribution of the validator	Example: 2009-12-25
4.5	Contribute (Validator)	Those entities (i.e., people or organizations) that have contributed to the validation of this metadata.	

Table 3.5: *Step 5-Technical: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
5	Technical	This category describes the technical requirements and characteristics of this learning object.	
5.1	Format	Technical datatype(s) of (all the components of) this learning object.	text/plain text/html text/css text/richtext text/xml text/rtf application/pdf application/zip application/msword application/msexcel application/mspowerpoint application/java-applet application/x-shockwave-flash image/fits image/jpeg image/gif image/tiff image/png audio/basic video/mpeg video/quicktime video/wmv
5.2	Browsers	Type of the required technology to use this learning object.	unix multi-os netscape communicator ms-internet explorer opera amaya none any
5.3	Operating Systems	The technical capabilities necessary for using this learning object.	pc-dos ms-windows macos unix multi-os none any
5.3.1	Minimum Version	Lowest possible version of the required technology to use this learning object.	Example: WIN XP
5.3.2	Maximum Version	Highest possible version of the required technology to use this learning object.	Example: WIN VISTA
5.4	Size	The size of the digital learning object in megabytes (MB) or kilobytes (KB)	Up to 250KB From 250KB to 500KB From 500KB to 1MB From 1MB to 5MB More than 5MB

Table 3.6: *Step 6-Educational: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
6	Educational	This category describes the key educational or pedagogic characteristics of this learning object	
6.1	Learning Resource Type	Specific kind of learning object.	exercice simulation questionnaire figure graph index slide table narrative text exam experiment lesson plan self assessment lecture Guided Research Inquiry-Based Teaching Project-Based Learning The 5E Instructional Model The Learning Cycle
6.2	Interactivity Type	Predominant mode of learning supported by this learning object.	**active:** learning by doing, supported by content that directly induces productive action by the learner. **expositive:** passive learning, occurs when the learner's job mainly consists of absorbing the content exposed to him/her (generally through text, images or sound) **mixed:** combines active and expositive learning
6.3	Interactivity Level	The degree of interactivity characterizing this learning object. Interactivity in this context refers to the degree to which the learner can influence the aspect or behavior of the learning object.	very low / low / medium / high / very high
6.4	Difficulty	How hard it is to work with or through this learning object for the typical intended target audience.	very easy / easy / medium / difficult / very difficult
6.5	Typical Learning Time	Approximate or typical time it takes to work with or through this learning object for the typical intended target audience.	0.25 didactic hour 0.5 didactic hour 1 didactic hour 2 didactic hours more than 2 didactic hours
6.6	Intended End User Role	Principal user for which this learning object was designed, most dominant first.	teacher author learner
6.7	Context	The principal environment within which the learning and use of this learning object is intended to take place.	school higher education teachers training other
6.8	Typical Age Range	Age of the typical intended user.	6-9 9-12 12-15 15-18 18-25 25+

Table 3.7: *Step 7-Rights: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
7	Rights	This category describes the intellectual property rights and conditions of use for this learning object.	
7.1	Cost	Whether use of this learning object requires payment.	yes no
7.2	Copyright and Other Restrictions	Whether copyright or other restrictions apply to the use of this learning object.	yes no

Table 3.8: *Step 8-Export LOM record to XML format: Element Explanation*

Element Number	Element Name	Explanation	Vocabulary
8	Export LOM record to XML format	This step describes the export of a Learning Object Metadata record of a specific learning material to an XML format	
8.1	XML file creation	After the completion of the seventh Step the user exports and saves on his computer the created XML file associated with the learning object	Save file

4. Inquiry Based Teaching

Over the last decade inquiry instruction has been introduced as the cornerstone to the science teaching standards. Within the context of the teaching standards, inquiry is defined as the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments (Linn, Davis, & Bell, 2004).

Inquiry Based Teaching is a teaching strategy where teachers facilitate student-centered learning and research, acting more as a colleague and guide rather than the dispenser of knowledge. The central aim is to develop students' intellectual autonomy. Adopting this strategy can become a powerful tool for teachers who want to develop students' capacity to think for themselves. For teachers who want to adapt situations for individual needs, it is also a good way to understand how a specific student thinks about a particular problem.

In this section, we present the development of an Educational Scenario Template for applying Inquiry Based Teaching at both primary and secondary education levels making use of the digital resources from the Discover the Cosmos Educational and Outreach Portal.

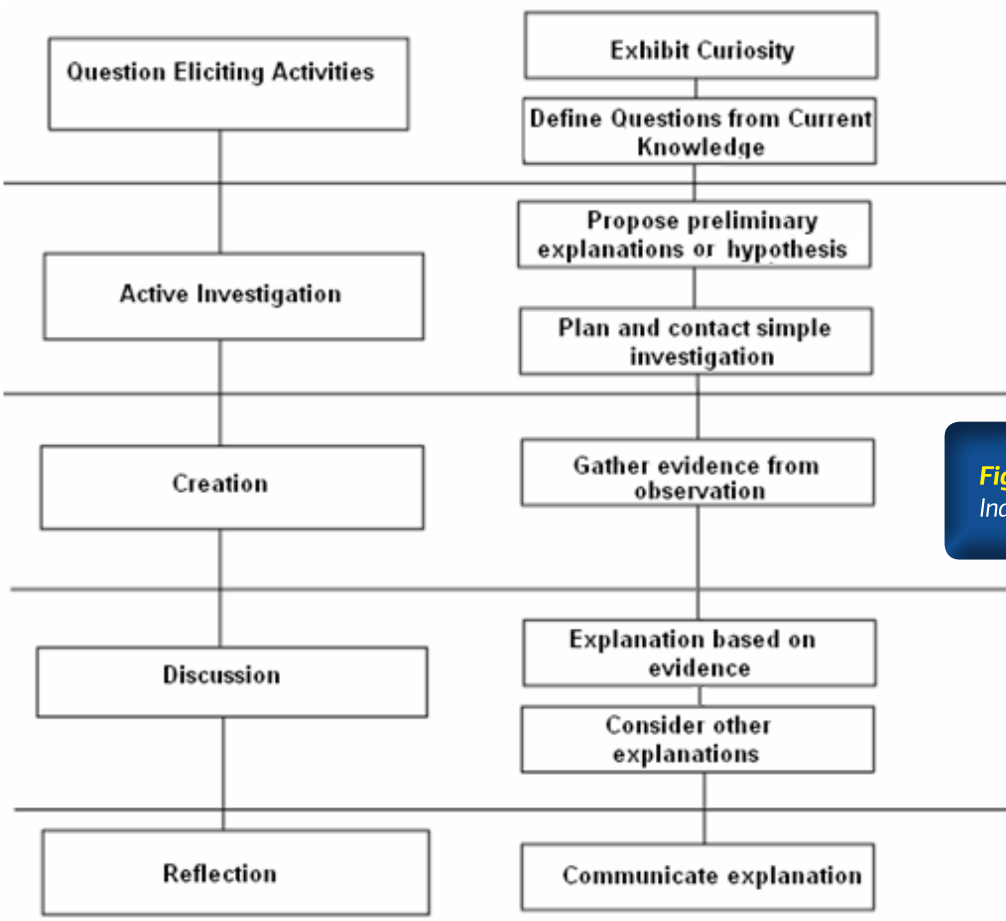


Figure 4.1: *Flow of Learning Activities for Inquiry Based Teaching*

4.1 Development of an Educational Scenario Template

4.1.1 Description of the Educational Scenario Template in Narrative Format

Describing an Educational Scenario Template	
1. Title of the Educational Scenario Template	Inquiry Based Teaching
2. Educational Problem	Main problems a theoretical and abstract teaching b. textbook based instruction c. no demonstration infrastructure available b. students misconceptions
3. Educational Scenario Template Objectives	**Knowledge** The learners should know and understand specific concepts and the analogies between them. **Skills** The students should be able to: • Explore the research procedures themselves • Perform research efforts that are taking place as a structured discovery within the frame of organised teaching. • Design and conduct scientific investigations. • Formulate and revise scientific explanations and models using logic and evidence • Recognise and analyze alternative explanations and models. **Attitudes** The students should be able to: • Acquire an appreciation for basic Science Education matters through the exposure in similar topics • Communicate and defend a scientific argument
4. Characteristics and Needs of Students	**Cognitive** The students have less than average knowledge level to mathematics and geometry. Limited knowledge of science subjects. **Psychosocial** Based on statistics less than 50% of the students have a significant interest in science (both boys and girls). A small number of them (about 15%) will follow careers in science (Sjøberg & Schreiner 2005, PISA 2006). **Physiological** The average age of students is 15-16 years. **Needs** The students should: • develop abilities necessary to do scientific inquiry • develop understandings about scientific inquiry • identify questions and concepts that guide scientific investigations • design and conduct scientific investigations • use technology and mathematics to improve investigations and communications • formulate and revise scientific explanations and models using logic and evidence • recognize and analyze alternative explanations and models • communicate and defend a scientific argument
5. Educational Approach of the Educational Scenario Template (a) Description of the Educational Approach rationale (b) Parameters that guarantee the implementation of the Educational Approach	(a) From a pedagogical perspective, **Inquiry Based Learning** is often contrasted with more traditional expository methods and reflects the constructivist model of learning, often referred to as active learning, so strongly held among science educators today. According to constructivist models, learning is the result of ongoing changes in our mental frameworks as we attempt to make meaning out of our experiences (Osborne et al, 2003). In classrooms where students are encouraged to make meaning, they are generally involved in “developing and restructuring [their] knowledge schemes through experiences with phenomena, through exploratory talk and teacher intervention” (Newton et al, 1999). However, we use inquiry based learning in a more specific manner, referring to a specific teaching model: an iterative process of (1) question eliciting activities, (2) active investigation by students, (3) creation, these are (4) discussed already at early stages of the process, leading to (5) reflection about knowledge and the learning process, which in turn leads to new and refined questions (1) and the process goes on for another cycle. (b) Students are likely to begin to understand the natural world if they work directly with natural phenomena, using their senses to observe and using instruments to extend the power of their senses. Moreover, students must have access to PCs that are connected to the Internet.

6. Learning Activities:	
Phase 1: Question Eliciting Activities	**Exhibit curiosity** The teacher tries to attract the students' attention by presenting/showing to them appropriate material. **Define questions from current knowledge** Students are engaged by scientifically oriented questions imposed by the teacher.
Phase 2: Active Investigation	**Propose preliminary explanations or hypotheses** Students propose some possible explanations to the questions that emerged from the previous activity. The teacher identifies possible misconceptions. **Plan and conduct simple investigation** Students give priority to evidence, which allows them to develop explanations that address scientifically oriented questions. The teacher facilitates the process.
Phase 3: Creation	**Gather evidence from observation** Teacher divides students in groups. Each group of students formulates and evaluates explanations from evidence to address scientifically oriented questions.
Phase 4: Discussion	**Explanation based on evidence** The teacher gives the correct explanation for the specific research topic. **Consider other explanations** Each group of students evaluates its explanations in light of alternative explanations, particularly those reflecting scientific understanding.
Phase 5: Reflection	**Communicate explanation** Each group of students produces a report with its findings, presents and justifies its proposed explanations to other groups and the teacher.
7. Participating Roles:	**Students** •Perform scientific prediction •Recording observations •Perform prediction compared to results •Develop experimental models **Group Participant** •Use or evaluate a technique •Use science to explain **Teacher** •Presents ideas and evidence in science •Asks questions •Identifies misconceptions •Applies scientific methods •Develops experimental models •Provides historical and contemporary examples
8. Tools, Services and Resources	**Tools:** Hardware •Computer •Projector Software •Text, image, audio or video viewer •Database •VLE **Resources:** •Figure, graph, slide, problem statement, simulation, experiment, table, self assessment, exercise, questionnaire, exam.

Table 4.1: Description of the Educational Scenario Template

4.2 Description of the Educational Scenario Template in Common Terms

4.2.1 Question Eliciting Activities

Phase 1 Question Eliciting Activities	Type	Technique	Interaction	Roles	Tools/ Services	Resources
Exhibit Curiosity	Communicative 1 Presenting	Information Handling Brainstorming	Who Class Based Medium Face to Face Timing Synchronous	Facilitator, Individual Learner	Hardware Computer,Projector Software Text, image, audio or video viewer	problem statement
Define Questions from current knowledge	Communicative Debating	Information Handling Brainstorming	Who Class Based Medium Face to Face Timing Synchronous	Facilitator, Individual Learner	Hardware Computer, Projector Software Text, image, audio or video viewer	other

Table 4.2: Question Eliciting Activities

4.2.2 Active Investigation

Phase 2 Active Investigation	Type	Technique	Interaction	Roles	Tools/ Services	Resources
Propose preliminary explanations or hypotheses	Productive Synthesising	Adaptive Modeling	Who Class Based Medium Face to Face Timing Synchronous	Facilitator, Individual Learner	Hardware Computer, Projector Software Text, image, audio or video viewer	problem statement
Plan and contact preliminary investigation	Experiential Exploring	Experiential Experiment	Who Class Based Medium Face to Face Timing Synchronous	Facilitator, Individual Learner	Hardware Computer, Projector Software Text, image, audio or video viewer	simulation

Table 4.3: Active Investigation

4.2.3 Creation

Phase 3 Creation	Type	Technique	Interaction	Roles	Tools/ Services	Resources
Gather evidence from observation	Experiential Experiencing	Adaptive Modeling	Who Group Based Medium Online Timing Synchronous	Facilitator, Group participant	Hardware Computer Software Database VLE	graph

Table 4.4: Creation

4.2.4 Discussion

Phase 4 Discussion	Type	Technique	Interaction	Roles	Tools/ Services	Resources
Explanation based on evidence	Information Handling Analysing	Communicative Structured debate	Who Class Based Medium Face to Face Timing Synchronous	Presenter, Group participant	Hardware Computer Software Text, Image, Audio or Video Viewer VLE	graph
Consider other explanations	Experiential Exploring	Communicative Arguing	Who Group Based Medium Online Timing Synchronous	Facilitator, Group participant	Hardware Computer Software Text, Image, Audio or Video Viewer VLE	other

Table 4.5: Discussion

4.2.5 Reflection

Phase 3 Creation	Type	Technique	Interaction	Roles	Tools/ Services	Resources
Communication of the explanation	Communicative Debating	Productive Report	Who Class Based Medium Face to Face Timing Synchronous	Facilitator, Group participant	Hardware Computer Software Text, Image, Audio or Video Viewer Models	other

Table 4.6: Reflection

4.3 Annex

The vocabulary used for the Learning Activities description in common terms, is explained in the following table:

Dimension	Type and Value	Description
Type	Communicative: Presenting	Presentation of a specific subject/work
	Communicative: Debating	A structured discussion of opposing points of view
	Information Handling: Analysing	Analysing a concept or a problem
	Productive: Synthesizing	Synthesizing data into a new whole
	Experiential: Exploring	Students give priority to evidence, which allows them to develop explanations that address scientifically oriented questions.
	Experiential: Experiencing	Performing experiments and observations
Technique	Information Handling: Brainstorming	A problem or idea is defined and all participants make suggestions related to the topic.
	Adaptive: Modeling	Formulate models to explain hypotheses or findings from the observations
	Experiential: Experiment	Designing, Setting up and Performing experiments
	Communicative: Structured Debate	A structured debate based on evidence from observations
	Communicative: Arguing	A verbal dispute
	Productive: Report	Production of a report describing the process and the findings
Interaction	Who: Class based	In the context of the classroom
	Who: Group based	In the context of the groups
	Medium: Face to Face	Face to face interaction of the participating role with others or content
	Medium: Online	Interaction via the use of Internet
	Timing: Synchronous	Synchronous interaction of the participating role with others or content
Roles	Individual Learner	The individual learner
	Group participant	A student participating in a group of students
	Facilitator	The teacher in a role of facilitator of the learning process
	Presenter	The teachers presents the outcomes of the discussion/debate

Tools/ Services	Hardware: Computer	An electronic, digital device that stores and processes information
	Hardware: Projector	A hardware device that enables an image to be projected onto a flat surface
	Software: Text, image, audio or video viewer	A software tool for displaying text, images, audio or video
	Software: Database	Educational Digital Library (e.g. DSPACE Library)
	Software: VLE	Virtual environment which engage users in learning activities (e.g. COSMOS portal)
Resources	Problem Statement	Document for defining a problem
	Slide	Hypermedia document
	Figure	A figure is any graphic, text, table or other representation that is un-aligned from the main flow of text
	Graph	Pictorial representation of information
	Exercise	Document for practicing a skill or understanding
	Simulation	An application that imitates a physical process or object by causing a computer to respond mathematically to data and changing conditions as though it were the process or object itself
	Table	An arrangement of information in columns and lines
	Self assessment	An assessment or evaluation of oneself, one's actions or attitudes by oneself
	Questionnaire	A list of questions by which information is sought from a selected group
	Exam	Document for testing, the knowledge or ability of students
	Other	It can be any of the following resources: Figure, graph, slide, simulation, experiment, table, self assessment, exercise, questionnaire, exam

Table 4.7: Learning Activities description

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