Fostering creativity in learning through digital games

C²Learn
creative learning

Creative Emotional Reasoning Computational Tools Fostering Co-Creativity in Learning Processes

C2LEARN CONTENT REPRESENTATION

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EXECUTIVE SUMMARY

C^{2}Learn at a glance

C^{2}Learn (www.c2learn.eu) is a three-year research project supported by the European Commission through the Seventh Framework Programme (FP7), in the theme of Information and Communications Technologies (ICT) and particularly in the area of Technology-Enhanced Learning (TEL) (FP7 grant agreement no 318480). The project started on 1st November 2012 with the aim to shed new light on, and propose and test concrete ways in which our current understanding of creativity in education and creative thinking, on the one hand, and technology-enhanced learning tools and digital games, on the other hand, can be fruitfully combined to provide young learners and their teachers with innovative opportunities for creative learning. The project designs an innovative digital gaming and social networking environment incorporating diverse computational tools, the use of which can foster co-creativity in learning processes in the context of both formal and informal educational settings. The C^{2}Learn environment is envisioned as an open-world 'sandbox' (non-linear) virtual space enabling learners to freely explore ideas, concepts, and the shared knowledge available on the semantic web and the communities that they are part of. This innovation is co-designed, implemented and tested in systematic interaction and exchange with stakeholders following participatory design and participative evaluation principles. This happens in and around school communities covering a learner age spectrum from 10 to 18+ years.

About this document

Deliverable D4.2b provides details on the Content Representation needs of C2Learn, analyzing the different standards and technologies applicable to the problem and examining their suitability for the specific requirements posed by the C2Learn content.

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LIST OF TERMS AND ABBREVIATIONS

Term/Abbreviation	Definition
LT	Learning Technologies
RTE	Run-Time Environment
SCO	Sharable Content Object
SCORM	Sharable Content Object Reference Model
XML	Extensible Markup Language

1.   INTRODUCTION

The activities supported by C2Learn are centred on Game Sessions, which involve the invocation of one or more C2Learn Games. The following figure depicts the core components of the architecture serving the C2Learn activities, along with their interrelations. The components comprising the architecture are the following:

C2Space is the overall environment serving the different distinct C2Learn Games

– The *Game Registry* is part of C2Space and contains and delivers information for the games that are available for usage in game sessions. The Game Registry relies on metadata for describing the games, which are located in a relevant *Game Repository*.
– The *Game Session Registry* is part of C2Space and stores the information for the game sessions. It is used by the relevant games in order to determine the appropriate enrolment process and setup.
– The *C2Learn Games* are the actual games used by the game session. They are responsible for the enrolment process of the users playing the game either as group members or as single players.
– The *Creativity Profiling Server* communicates with the C2Learn Games and collects the artefacts created by the players, in order to (a) calculate the Computational Creativity Metrics for these artefacts and (b) update the user's creativity profiles.

The described architecture poses the representation and communication requirements that must be satisfied in order to integrate the distinct architectural components in a way that will ensure (a) that the platform is easily extensible with different games and class settings, and (b) that the produced content will be able to be incorporated with minimal effort in different learning environments.
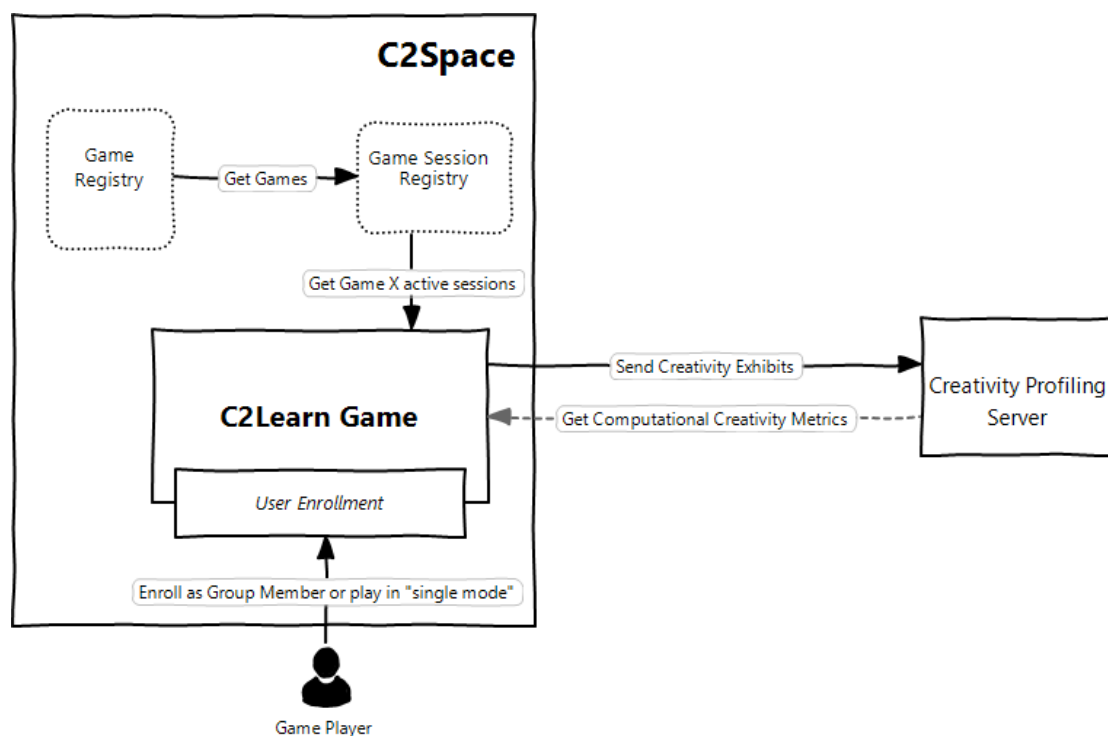

Figure 1: Overall Architecture

More specifically, in order for a game to become available in C²Learn Game Sessions, it has to be declared in the *Game Registry*. To this end, the game should provide metadata regarding its usage and requirements. The metadata also include a pointer to the *Game Repository*, where the actual game is available.

The next step is to define a Game Session, i.e. define the game to be used and the participating players. The produced game session definition is stored in the *Game Session Registry*.

As the players participating in a Game Session proceed with their creations, the latter are sent to the Creativity Profiling Server (CPS). As the provided C2Learn Games are not designed to be adaptive with respect to user characteristics, but they adapt the game progress based on the evolution of the users' creation at hand, the updated version of the C2Learn Creativity Profiling Server aims to identify patterns of creativity by analysing the produced artefacts using machine learning and data mining techniques. Towards this, it collects and processes information pertaining to all CER techniques, expressed in different modalities (for further details, cf. D3.4.2b).

The aim of this deliverable is to identify the constituents of the C2Learn architecture that need to bear a specific, standard-conformant representation and to examine the relevant and appropriate specifications that can serve this purpose. The communication requirements, and the respective standards to be used for satisfying them, will be analysed in deliverable D3.5, Computational Tools Interoperability Specification.

2.   C2LEARN INTEROPERABILITY REQUIREMENTS

Taking into account the architecture depicted in Figure 1, we identify the following elements that require a standardized representation in order to ensure the interoperability of the associated components and assets. These elements are summarized in the following table.

Representation Requirements			
Architectural Element	**Representation Requirement**	**Importance**	**Candidate Standard / Spec**
Game Registry	The metadata describing the game should follow a standard schema / formulation	Mandatory	IEEE LOM Dublin-Core
Game Repository	The games available in C²Learn should be packaged and distributed in a standard way	Mandatory	IMS CP SCORM 2004

Table 1: C²Learn Representation Requirements

The representation requirements will be analysed in the following sections of this document. The communication requirements will be analysed in deliverable D3.5, Computational Tools Interoperability Specification.

3.   RELEVANT STANDARDS & SPECIFICATIONS FOR THE C2LEARN REPRESENTATION REQUIREMENTS

3.1   GAME REGISTRY

The Game Registry is responsible for maintaining and serving information about the games available in C2Learn. Each of the games should provide information regarding its provenance and its general characteristics (language, usage description etc.). To this end, the game registry should use a standard resource description model for representing the metadata of each game. The candidate specifications that are most relevant to the purposes of C2Learn is the *IEEE Learning Object Metadata* (LOM) standard and the *Dublin Core Metadata Initiative* (DCMI) model.

The IEEE Learning Technology Standards Committee (LTSC) is responsible for the development and maintenance of the Learning Object Metadata (LOM) standard (IEEE, 2002) since 1997. This process has been and continues to be an international effort with the active participation on the LOM Working Group by members representing more than 15 countries. This resulted in the first IEEE accredited standard to be completed by LTSC, the 1484.12.1 LOM data model standard. This is the first of a multi-part standard for Learning Object Metadata, which LTSC LOM is responsible for

maintaining, developing and evolving. This responsibility is being fulfilled by current work on bindings of the data model standard and includes developing further versions of the data model standard. The IEEE LOM standard has been well received, recognized and adopted internationally.

The elements of the IEEE LOM standard are organized in the following categories:

– *General*. This category groups the general information that describes a learning object as a whole.

– *Life Cycle*. This category describes the history and current state of a learning object and those entities that have affected the learning object during its evolution.

– *Meta-Metadata*. This category describes the metadata record itself (rather than the learning object that the metadata record describes).

– *Technical*. This category describes the technical requirements and characteristics of a learning object.

– *Educational*. This category describes the key educational or pedagogic characteristics of a learning object.

– *Rights*. This category describes the intellectual property rights and conditions of use for a learning object.

– *Relation*. This category defines the relationship between a learning object and other learning objects.

– *Annotation*. This category provides comments on the educational use of a learning object, and information on when and by whom the comments were created.

– *Classification*. This category describes where a learning object falls within a particular classification system.

Figure 2 presents a generalized view of the structure of the IEEE LOM standard metadata model.
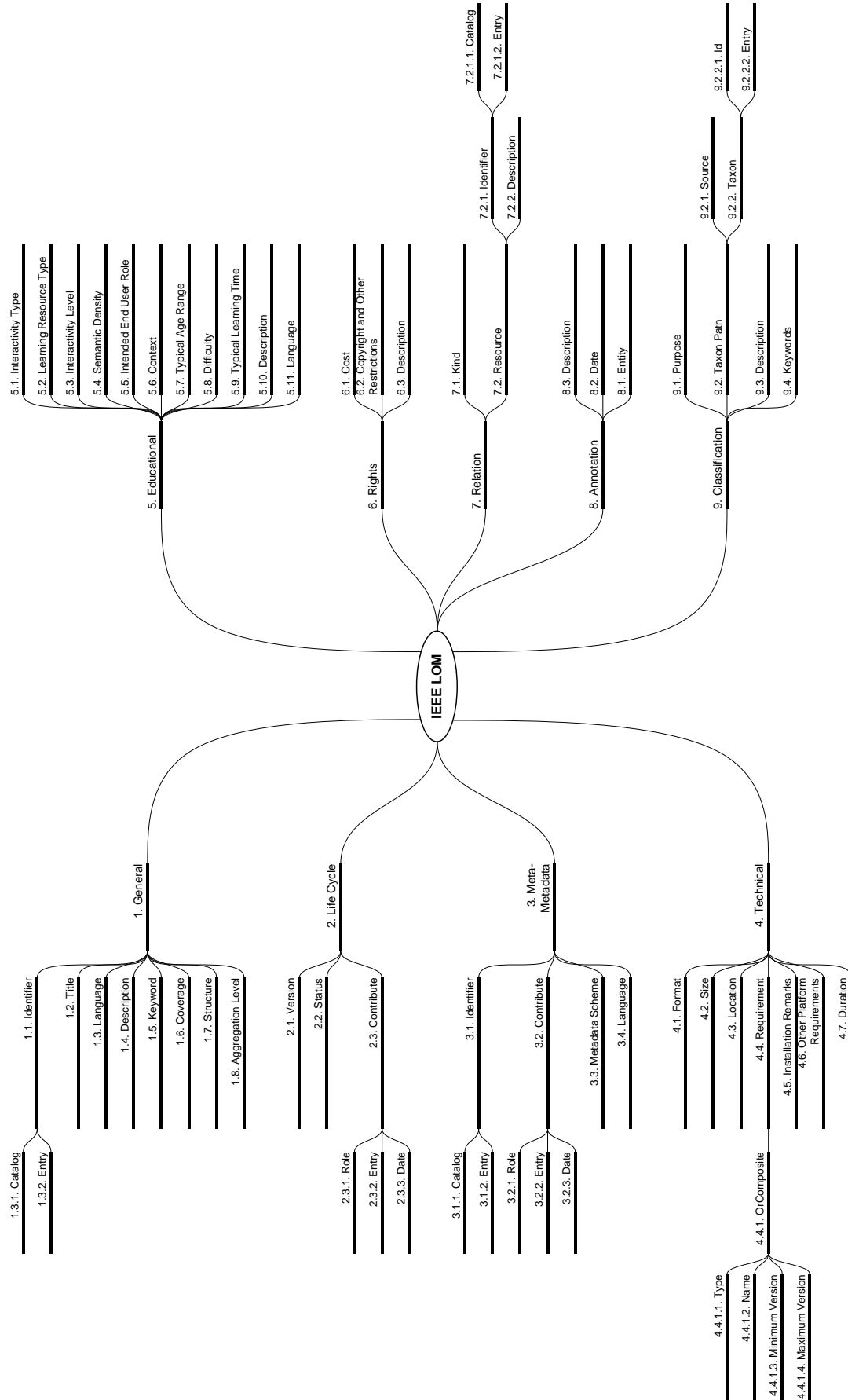
Figure 2: IEEE LOM Elements

The IEEE LOM model consists of about eighty (80) elements, many of which can have multiple instances in the description of a single object. The inherent complexity of the model results to a difficult to maintain representation, while the level of detail provided by IEEE LOM is not necessary for representing in full the C2Learn games.

On the other hand, the Dublin Core Metadata Element Set (Dublin Core Metadata Initiative, 2012) is a vocabulary of fifteen properties for use in resource description. The name "Dublin" is due to its origin at a 1995 invitational workshop in Dublin, Ohio; "core" because its elements are broad and generic, usable for describing a wide range of resources. The fifteen element "Dublin Core" described in this standard is part of a larger set of metadata vocabularies and technical specifications maintained by the Dublin Core Metadata Initiative (DCMI). The full set of vocabularies, DCMI Metadata Terms, also includes sets of resource classes (including the DCMI Type Vocabulary), vocabulary encoding schemes, and syntax encoding schemes. The terms in DCMI vocabularies are intended to be used in combination with terms from other, compatible vocabularies in the context of application profiles and on the basis of the DCMI Abstract Model.

The simplicity of the core recommendation of the Dublin Core Metadata Element Set, combined with the ease of extensibility that it provides by its definition, makes it a suitable candidate for usage within the C²Learn Game Registry. Furthermore, the IEEE LOM standard defines explicit mappings with Dublin Core, and thus a Dublin Core metadata description can be used from systems using the IEEE LOM standard without mapping ambiguities.

The C2Learn Game Registry will use the following subset of Dublin Core Metadata Elements. This set will be extended with two additional elements that will be used to define the minimum and maximum number of groups that the given game's gameplay supports. The following table summarizes the elements that will be used for providing metadata about the C²Learn games.

C2Learn Element	Description	Dublin Core Element	IEEE LOM Element
URL	The location from where the game can be accessed	DC:identifier	General.Identifier.Entry General.Identifier.Catalog = "URL"
Title	The title of the game	DC:title	General.Title
Language	The languages supported by the game	DC:language	General.Language
Description	A short description of the game's functionality	DC:description	General.Description
Date	The date the game was registered	DC:date	LifeCycle.Contribute.Date LifeCycle.Contribute.Role = "Publisher"
Publisher	The entity that published the game	DC:publisher	LifeCycle.Contribute.Entity LifeCycle.Contribute.Role = "Publisher"
Rights	A licence / ToU for the game	DC:rights	Rights.Description
minGroups	The minimum number of groups that is supported by the game	-	-
maxGroups	The maximum number of groups that is supported by the game	-	-

Table 2: C2Learn Game Description Elements and their mappings

3.2   GAME REPOSITORY

As mentioned, the Game Registry includes information for locating and retrieving the actual game deployment. In addition to being able to locate the game, it is essential that the game is distributed in a standard package structure, so that it can be used within different environments. Hence, we need to examine relevant standards and specifications for packaging digital content and assess their applicability for the specific C²Learn content (the C²Learn games).

Currently, the most adopted model for content packaging is the IMS Content Packaging Specification (IMS Global Consortium, 2004). The objective of IMS CP is to define a standardized set of structures that can be used to exchange content. The scope of IMS CP is on defining interoperability between systems that wish to import, export, aggregate, and disaggregate packages of learning content.

This specification has been adopted by the ADL as part of the SCORM reference model.

An IMS Content Package contains two major components:

1. *a (required) special XML document describing the content organization and resources of the package. The special file is called the Manifest file (imsmanifest.xml) because package content and organization is described in the context of manifests.*

2. *the physical files referenced in the Manifest.*

Sharable Content Object Reference Model (SCORM) (ADL, 2004) refines the IEEE LTSA reference architecture by specifying missing interactions. More precisely, SCORM provides a reference interaction model between a learner and learning content, and describes within a common technical framework the creation process of reusable learning content as "instructional objects", called sharable content objects (SCOs). SCORM describes that technical framework by providing a harmonized set of guidelines, specifications, and standards based on the work of several distinct e-learning specifications and standardization bodies. SCORM consists of three parts, namely:

− Run-Time Environment (RTE). The purpose of the SCORM RTE is to provide a means for interoperability between SCOs and LMSs. SCORM provides the means for learning content to be interoperable across multiple learning systems regardless of the tools used to create the content. The three components of the SCORM RTE are Launch, Application Program Interface (API) and Data Model. Launch includes defining the relationship between learning systems and SCORM content such that all SCORM-conformant content is dependent upon a SCORM-conformant learning system to be delivered and displayed to the learner. The SCORM API provides a set of predefined methods for purposes of communication between a learning system and the SCOs it launches. The SCORM Run-Time Environment Data Model provides the data elements that can be used to "get" and "set" data from and to a learning system.

− Sequencing and Navigation (SN). The SCORM SN covers the essential learning system responsibilities for sequencing content objects during run-time and allowing SCOs to indicate navigation requests. The SCORM SN is based on the IMS Simple Sequencing (SS) Specification v1.0, which defines a method for representing the intended behavior of an authored learning activity such that any conformant learning system will be able to sequence discrete content components in a consistent way. It defines the required behaviors and functionalities that SCORM-conformant learning systems must implement to process sequencing information at runtime. More specifically, it describes the branching and flow of learning content in terms of an Activity Tree, based on the results of a learner's interactions with launched content objects and an authored sequencing strategy. The SCORM SN describes how learner-initiated and system-initiated navigation events can be triggered and processed, resulting in the identification of learning content for delivery.

− Content Aggregation Model (CAM). The SCORM CAM describes the content components used in a learning activity, how to package those components for exchange from system to system and how to describe those components to enable search and discovery. The CAM promotes the consistent storage, labeling, packaging, exchange and discovery of learning content. The SCORM CAM model contains information on Metadata, Content Structure and Packaging. The SCORM CAM model extends the IMS CP specification.

Within C2Learn, we will use the SCORM CAM model for packaging the C2Learn games. The metadata accompanying the game's distribution will essentially be the metadata for the game provided by the game registry. In order to be compliant with the specification the game SCORM CAM package will include these metadata expressed in the IEEE LOM model, via the mapping defined in Table 2.

4. CONCLUSIONS

The C2Learn environment and the respective architecture pose specific representation and communication requirements for the involved content and components. It is highly desirable and particularly important to use widely adopted and well-supported standards and specifications for fulfilling these requirements and ensuring that the C2Learn outcomes can be reused and incorporated with minimal effort in other standard-conformant platforms and systems.

The present deliverable reports on the standards and specifications for satisfying the C2Learn representation requirements. Standards from three different fields are adopted, depending on the nature and functionality of the entities that are to be represented:

- From the field of Learning Technologies, we will use the IEEE LOM, IMS CP, SCORM and IMS LD standards
- From the field of Resource Description, we will use the Dublin Core Metadata Element Set.

The C²Learn communication requirements will be similarly analysed in deliverable D3.5, Computational Tools Interoperability Specification.

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