# Interoperability and Semantic Filtering

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## Abstract

Interoperability is often seen only as a technological problem related to reusability. We would like to give interoperability a new role in the structure of the learning environment and in collaborative activities. For us interoperability is also connected with didactical, semiotic and cultural aspects. It improves the interaction between the materials produced with different tools, the construction of kaleidoscopic artifacts and the reflection on the learning process.

# 1. Introduction

Some terms used in the new technology field seem to have only one unique and predetermined meaning to a non-attentive observer. But if we start exploring the usage of certain terms by different authors and in different approaches, we will notice that the meaning is not identical or shared.

One of these terms is «interoperability».

«Interoperability means the ability of software and hardware on different machines from different vendors to share data».[1] A similar definition from Management and Promotion of Electronic Government Services states «Interoperability means the ability of different operating and software systems, applications, and services to communicate and exchange data in an accurate, effective, and consistent manner».

Federal Communications Commission, Common Carrier Services and Interconnection say: «Interoperability means the ability of two or more facilities, or networks, to be connected, to exchange information, and to use the information that has been exchanged». Another similar definition is provided by Copyright Protection and Management Systems and by IEEE – 90.[2]

In all definitions we can find two main different concepts: the data exchange and the use of information. The second concept includes the first one but it requires also a semantic competence.

From a technological point of view, interoperability, in the context of distance learning, calls for a unified way for applications running on different hosts to be able to ask for, and exchange data. For this purpose several standardized communication protocols have been created. These range from primitive low-level protocols that govern the transfer of raw data between hosts to abstract high-level protocols that enable applications to directly send and receive data from each other.

Interoperability requires various approaches which are already known in theoretical computer science communities. The most general is «polymorphism» (Cardelli & Wegner, 1985). It provides interoperability on two different levels: data level and operation level (tools). The most common (or popular) way to implement polymorphism, to provide true interoperability, is to use an object-oriented approach (OOA). The problem with OOA is that it starts from a common ancestor who defines a concept (or general class project). This class represents a root and is extended to all other classes. In practice, direct implementation of such an approach is next to impossible as tools and data are produced completely independently. Therefore we replace a pure OOA with a more engineered approach where we ensure interoperability through standardization. The standardization defines

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[1] http://wi-fiplanet.webopedia.com/TERM/I/interoperability.html
[2] http://www.nlm.nih.gov/csi/bhb_brief.pdf

the interface and functionality of tools and the structure of data. The data are defined only through their structure. Semantics is missing, therefore additional meta-tags could be a possible solution. Such meta-tags are previously created and cannot always support future productions of artifacts according to the approaches from different perspectives.

This paper will try to identify alternative solutions to the single introduction of meta-tags, introducing tools/environments to facilitate the semantic interoperability, analyzing the role of semantic filtering and describing a few experimental examples realized in different locations.

## 2. Interoperability and education

Let's have a look now at the concept of interoperability according to the SCORM model, produced by the Advanced Distributed Learning Consortium, the most used reference for the standardization of on-line learning. «The purpose of the SCORM RTE (Run Time Environment) is to provide a means for interoperability between SCOs and LMSs. SCORM provides a means for learning content to be interoperable across multiple LMSs regardless of the tools used to create the content» (ADL, SCORM Content Aggregation Management 1.3.1, 2004, p. 15).

In the overview, SCORM proposes Individual Instruction and a one-on-one relationship as the most effective perspective in the educational field compared to the one-to-many classroom-based instruction. It does not present a training perspective using the many-to-many relations or peer to peer activities. There is no mention of on-line activities, such as forum, chat, documents sharing or group-based planning activities, requesting an interaction between students.

The model proposed for the Learning Objects (LO) is shown in figure 1.

In such a didactical model the interoperability guarantees the dialogue between the LMS (Learning management system) and the LO and does not interfere with the didactical activities.

The situation is different when we ask the student to negotiate meanings, make projects and reflect on his/ her learning path.
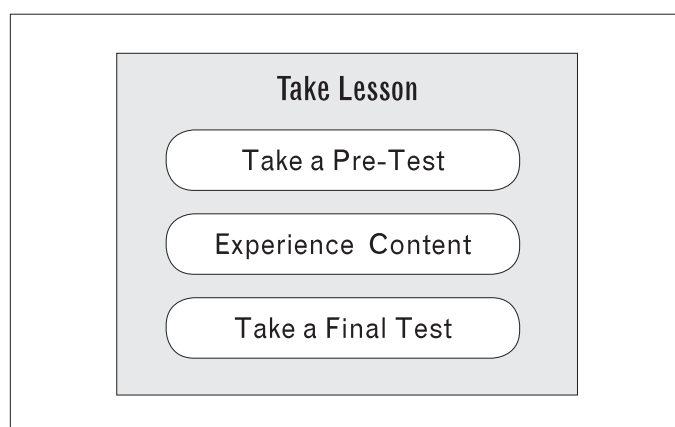
If the activities impose the production of complex



**Figure 1**    Sample of Learning Activity from SCORM 1.3.1.

artifacts, thanks to the interaction between fragments taken from different tools, (they can be texts, forum debates, chats, documents downloaded by teachers and students) then an interoperability between objects and tools is required, to provide a semantic aspect in the learning environment. Semantic interoperability helps more complex operations related to the social construction of knowledge. According to semantic interoperability, the final user has to build complex and kaleidoscopic artifacts with the messages and information present in other tools and has to realize activities in which it is necessary to work at the same time with different tools.

If we analyse the definition given to interoperability by the Eportconsortium,[3] we will notice that the objectives are different (for example the setup of an e-portfolio), and therefore also the interoperability concept is different from the one presented by SCORM. The Eportconsortium White Paper collects all the meanings that the term interoperability can assume and include «the access to information about users across systems, the access to data created by users across systems, the Standardization of data structures describing objects within a portfolio, the structure of ePortfolio components, views of the portfolio, and the whole portfolio, the Sharing common authentication and authorization services with other systems, the Mapping data between educational communities, the Enforcing verifiability, non-revocability, and IP rights across systems, the Managing workflow across systems» (Eportconsortium, 2003).

As we can see from the short descriptions, interoperability takes two meanings: first, to create an artifact in one environment usable also outside of that environment and second, to make the user capable to accessing the data in the tools and environment, to reuse them and also to build artifacts and kaleidoscopic materials with materials inside or outside the learning environment. We emphasize the important role of the final user and driving towards a student-centered focus.

A complex approach to interoperability we discussed so far addresses the problem of multi-lingual and multi-cultural environments. In the EU this problem is particularly important and relevant. We are addressing the area of education or, more precisely, ICT supported education in multicultural EU. Therefore the interoperability issue needs to address also the interoperability between different cultural environments.

## 3. Environments for semantic interoperability

To guarantee a semantic interoperability a learning environment should have these four characteristics:

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[3] Eportconsortium is a consortium composed of software houses, research centres and universities.

– the materials (inserted by teachers or students) are structured in easy to select components. These components can be accessed from a single tool /LO and they are usable throughout the environment. To make this possible the materials should be organized in archives (a database or xml files) for sharing across the various tools in the environment;

– the tools can «dialogue» between them and not only with the LMS, that means they can exchange data;

– the LMS, not only guarantees the activation of the LO and the exchange of information with a single LO, but has functions to produce kaleidoscopic artifacts and has to be able to index the materials within; as a result the environment becomes a meta-tool;

– in the environment there is a search engine that works according to a semantic filtering system or «social taxonomies».

## 3.1 Tools for the combinatorix

The kaleidoscopic writings are based on the concept of the combinatory writing (Calvino, 1995; Barthes, 1974; Queneau, 1961; Borges, 1994) and of the deconstructionism (Derrida, 1998). We define kaleidoscopic writing as the possibility to build artifacts connecting materials or fragments of materials in the environment, producing a jigsaw puzzle or patchwork.

In some tools the structure in which messages are contained is automatic, while the single messages are produced by the users. The structure becomes the co-text[4] of the message. The relation between text and co-text created in tools such as forums, messaging programs, chats and blogs, promotes the combinatorix (Petöfi, 1969; Petöfi, 2004). In the learning objects (LO), the structure and the texts are realized by a single author without any intervention from the student. The product is given to the user and it is requested from the user a limited participation: to read and answer the questions. In the interactive tools text and co-text is developed by different profiles that operate in different times. The initial plan develops the structure of the forum that will build itself automatically (the co-text) when the user inserts materials (texts). These tools, unlike LO, are open products.

## 3.2 The «dialogue» between tools

To talk about interoperability we need to move one step further. If the objective is to realize a complex activity (negotiation, building of knowledge, decision making and reflection), thanks to the synergy between different tools operating both synchronously or asynchronously, the granularity of the messages contained

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4 We define co-text as the part of the text that we find around a given linguistic unit (Notions of Glottodidactics in http://venus.unive.it/italslab/nozion/nozc.htm).

in the interactive tools facilitates interoperability between tools but we need also an IT structure to support that kind of work.

Here are some of the possible architectures:

1. Tools for negotiation. Negotiation consists of two important moments: (a) discussion in the group to share and focus on all points of view and to test them in relationship to the others and (b) the reification, the collective production of artifacts that will make explicit the shared concepts. So, from the forum necessary for the discussion, it is important to switch to tools that will make it possible for the production of a final artefact that will summarize all shared knowledge. The use of different, but interoperable tools, allows users to review the various concepts from the different perspectives. In this phase it is possible to use a *mapping tool* (as described below) that allows to add, in the single node, parts of the material coming from other artifacts or the whole; or tools for *interactive writing* that allow to insert tags and links to the previous writings in forums or other tools. Interoperability has to ensure that the list of materials to insert in the nodes of the map or the url of the materials to connect will be given automatically, independent on the tool .

2. Tools for planning and design. The project team needs to operate simultaneously on two levels: (a) discussion and organization, (b) design and delivery of the project. For these two levels we need different tools which operate in a parallel form. On-line synchronous delivery modes have been tested in which the audio chat was combined with a shared writing space, visible by everyone. A similar tool called Marratech Pro for group communication and collaboration over the Internet has been developed at Luleå University (Parnes et al., 2000).

Via the tool, a group of people working together can meet (synchronously) using live video and audio streams. This takes nothing but a standard web camera, a microphone and a connection to the Internet. They can also write each other messages in a text chat. The communication takes place either in a common channel, that every participant is connected to, or in a private channel between one participant and another without the rest taking part. Different kinds of communication can take place at the same time. There can be one or more common multi-page whiteboards available. These can show entire pre-prepared webpages and documents but also sketches, text and symbols that are drawn/written on the fly. The tool makes it possible for the participants to collaborate efficiently by, for instance, working on and editing a Microsoft Word-document or to discuss, write, and sketch in real-time. Asynchronous communication is supported by the ability to save and later on open whiteboards again much like how simultaneous editing of documents is carried out.

3. e-portfolio. The e-portfolio, in the model proposed and tested by a research group from the University of Macerata, is a tool structured in three sections

(Rossi & Giannandrea, 2006). The first section collects a selection of materials coming from other tools, the second section organize them in a structure to build your own professional profile and the third one is a projection. In the projection phase the student indicates the personal objectives reached and his/her ongoing objectives.

In the selection phase materials can be inserted or taken from the environment and from the internet. For the materials' selection, every page of environment includes a drop-down menu with a button to «insert the page in the e-portfolio».

In the connection phase, it is possible to build a map with the materials (or part of them) selected before. With drag and drop capabilities it is possible to take materials from the selection phase and put them into a work-sheet. For producing maps (see figure 2) we have available a list of materials accessible in the learning environment and with the drag and drop function we have the ability to create a node, linking multiple pieces of content together.

Every material becomes a node of the map. It is then possible to connect the nodes with arches. This design builds a map to describe the acquired competencies: the produced materials and the reference theoretical materials become a personal representation of the user's competencies.
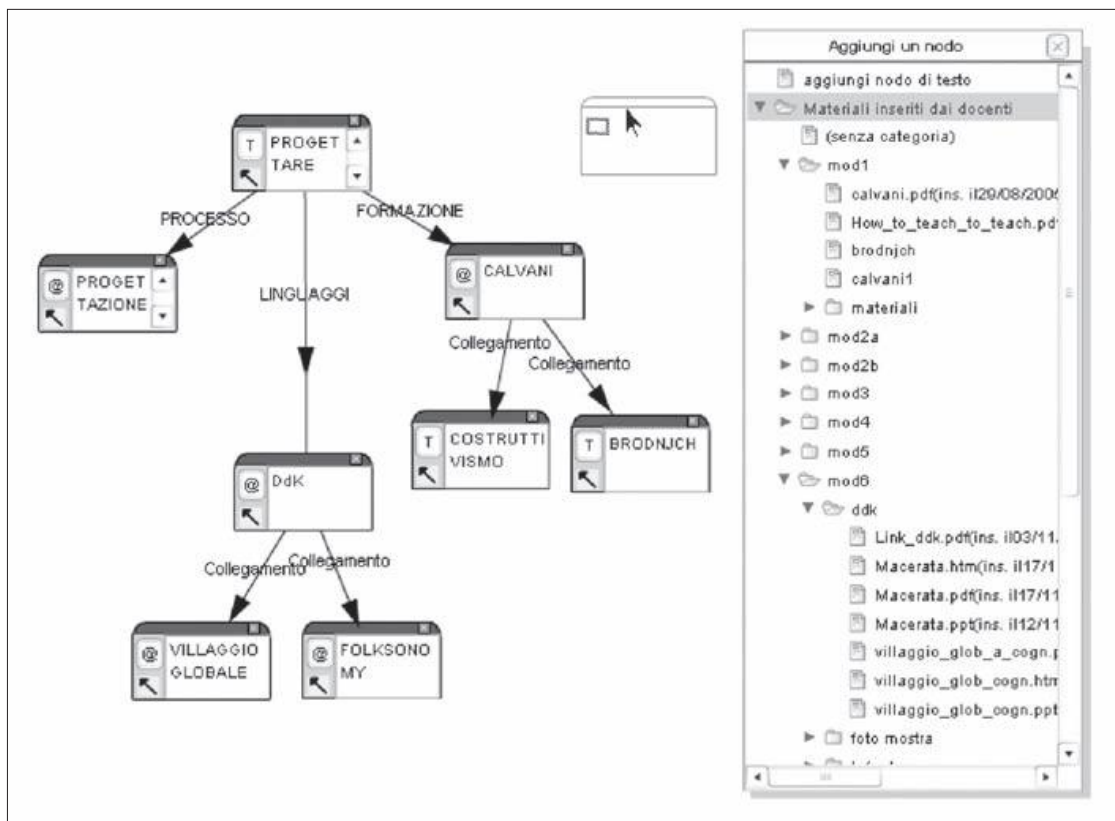


**Figure 2**    The mapping tool.

This kind of interoperability produces the model used to build the learning environment: in one case, the environment is the sum of the autonomous objects that exchange with the LMS data regarding the identity of the users and data related to the tracking of their activities. In the second case, we have a learning environment structured as a network of tools, communicating with each other, that exchange data between each, and this includes all or parts of materials produced inside a single tool (fig. 3).
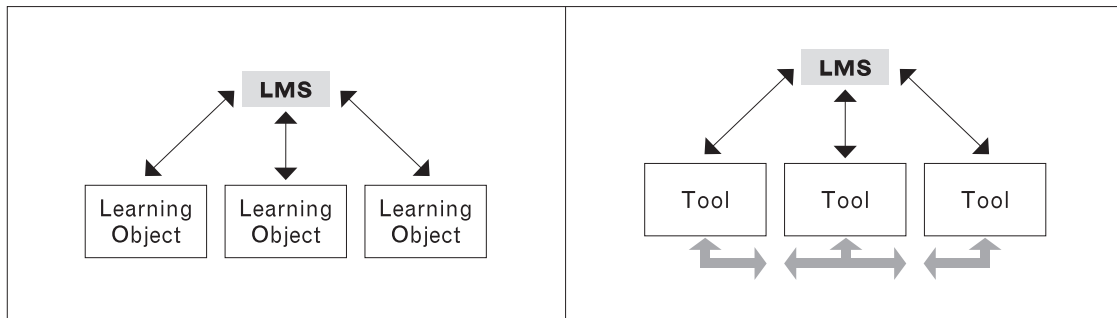


**Figure 3**     Two models to compare.

## 3.3 Environment as meta-tool

The «dialogue» between tools can be guaranteed by multiple external functions and executed by the LMS. They are functions common to all pages not connected with the objectives of a specific tool. Every page of the CELFI[5] environment provides a drop-down menu that allows to extract a page or a part of the page and to insert into a dossier or into a planning tool. It also allows to take notes within the same page and to insert a link that connects to other materials in other pages of other tools. Another function that the environment provides are tools to build kaleidoscopic artifacts. For example in this current environment we have a mapping tool, already described, that allows to connect materials in the environment and works as a meta-tool.

Environments working at a meta-level on the Internet (catalysts in connecting other sites) are the Folksonomy. Tools like WIKI, FLICKR, DEL.ICIO.US 24EYES, PENN STATE LIBRARIES DIGITAL COLLECTIONS (P2P Technologies) are applications technologically founded on the integration of different tools and on the interoperability. For example DEL.ICIO.US allows during the navigation to save on your own page (personal del.icio.us) the addresses of the explored pages, tagging them with key words, searching other recurrences in the tag in other personal DEL.ICIO.US. It

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[5] Developed by Giuseppe Alessandri and Matteo Macoratti and designed in collaboration with Pier Giuseppe Rossi at CELFI (Macerata University Integrated E-learning Center: http://celfi.unimc.it).

connects therefore the browser, the tree tag and a search engine, giving to the community the possibility to communicate and to create a network of bookmarks.

## 3.4 Automation tools to improve interoperability: the holistic semantic web and semantic filtering

The creation of kaleidoscopic artifacts have search engines that allow users to recover or to choose «scattered» fragments in the environment. Connectivity can be empowered by the possibility to exploit tools capable of automatically searching information and artifacts on the Web. Such tools can be further improved by personalization techniques, which allow guiding the searching and filtering process by means of personal profiles encoding the specific interests of a single user.

Tools for semantic (content-based) information filtering that learn dynamically and improve over time, allow overcoming the constraints of predefined metadata. With such tools, search is not only based on metadata attached to the artifact by its author during the initial creation phase, but it can rely also on metadata generated later by the analysis of a semantic engine. Tools devoted to content-based personalized information filtering have been developed by the Artificial Intelligence Laboratory of the University of Udine (Tasso & Omero, 2002; Brusilovski & Tasso, 2004).

The analysis is usually performed on a single artifact, but relevant additional information can be obtained also by combining several artifacts. At this point it is important to emphasize that the term *artifact* can be defined quite freely – for example, if we have a multimedia data where data is recorded separately for each media, then each recorded media can represent a separate artifact if it is separately manipulated. To extract additional knowledge, we want to combine artifacts, and this requires to establish some relationships between artifacts. These relations can be defined through explicit meta-tags or through implicit ones.

The development of the previous research can be improved by a closer relationship between Semantic Web and e-learning.

As emphasized by Naeve, Lytras, Nejdl, Balacheff, Hardin (2006) Semantic Web and E-Lerning propose similar themes but from different perspectives. For example the research on the «Expression of meaning» in Semantic Web is connected with «Content authoring» in E-Learning. «The direct relation of Semantic Web and e-learning combines the traditional content authoring process with the critical objective of expression of meaning. Issues like semantic mark-up, semantic retrieval, personalised (semi-) structured annotation and content conversion are prominent parts of a big research stream, in which the main concern is the development of semantic e-learning content» (Neave et al., 2006, p. 322).

Another connection exists between the «Ontological evolution» and the «Adaptive hypermedia». «The traditional adaptive hypermedia considerations in e-learn-

ing have been combined with ontological engineering, and a lot of flexible systems and accompanied methodologies have emerged. Issues like ontology construction, ontology integration, conceptual modelling and semantic conceptualisation reveal a new research agenda, in which the specifications of conceptualisations (ontologies) promote the performance of learning systems» (Neave et al., 2006, p. 323).

## 4. Conclusions

Interoperability finalizes the exchange of data and use of information. Semantic interoperability, on the other hand, enhances the interaction between tools during on-line activities; such activities can be grouped in 3 categories:

1. building complex and kaleidoscopic artifacts with the messages (or fragments) present in other tools;
2. realization of paths during which it is necessary to operate with more tools connected in «dynamic» networks;
3. construction of maps/narrations to make the different competences and professional identities explicit.

The semantic interoperability is supported by the following elements:

– a molecular structure of the material in the database shared by multiple tools;
– some functionalities of the environment;
– semantic filtering tools for messages.

A closer connection between Knowledge Management and e-learning will improve the process and overall experience. For this concept to evolve we need to rethink the actual standardization that still is based on learning modules that do not provide any or limited value to the interaction of many-to-many, to the the production of kaleidoscopic artifacts, to the reflection process and to the awareness of your knowledge building.

The research and testing that we are currently doing allowed us to prove and validate the didactical results of such tools in on-line learning courses.

# BIBLIOGRAPHY

ADL (2004), *SCORM 1.3.1* URL <http://www.adlnet.gov/scorm/index.cfm> accessed on 11th June 2006.

Barthes R. (1974), *S/Z An Essay.* Trans. Richard Miller, Hill and Wang, New York.

Borges J.L. (1994), La Bibliothèque de Babel, in *Fictions*, Gallimard, Paris.

Brodnik A. & Kljun M. (2004), *Computer lab and its services,* ERK 2004 261-264, Portorož, Slovenia.

Brusilovski P. & Tasso C. (Eds.) (2004), *Special Issue on Web Information Retrieval. User Modeling and User Adapted Interaction,* «The Journal of Personalization Research», 14(2-3): 145-288.

Calvino I. (1995), *Cibernetica e fantasmi,* in *Una pietra sopra*, Oscar Mondadori, Milano.

Cardelli L. & Wegner P. (1985), *On Understanding Types, Data Abstraction, and Polymorphism,* «ACM Computing Surveys», 4(17): 471-522.

Derrida J. (1998), *Della grammatologia*, Jaca Book, Milano.

Eportconsortium, White paper (2003), URL: <http://www.eportconsortium.org/Uploads/whitepaperV1_0.pdf> accessed on 11th June 2006.

Naeve A., Lytras M., Nejdl W., Balacheff N. & Hardin J. (2006), *Advances of the Semantic Web for e-learning: expanding learning frontiers,* «British Journal of Educational Technology», 37(3): 321-330.

Parnes P., Synnes K. & Schefström D. (2000), *mStar: Enabling Collaborative Applications on the Internet,* «Journal of Internet Computing», 4(5): 32-39.

Petöfi J.S. (1969), *On the problems of co-textual analysis of texts,* URL: <http://acl.ldc.upenn.edu/C/C69/C69-5001.pdf> accessed on 11th June 2006.

Petöfi J.S. (2004), *Scrittura e interpretazione. Introduzione alla Testologia Semiotica dei testi verbali,* Carocci, Roma.

Rossi P.G. & Giannandrea L. (2006), *E-portfolio*, Carocci, Roma.

Queneau R. (1961). *Cent Mille Milliards de Poèmes*, Gallimard, Paris.

Tasso C. & Omero P. (2002), *La personalizzazione dei contenuti Web*, Franco Angeli, Milano.