SYSTEMS THINKING FOR MEDIA NAVIGATION: A SUPPORT FOR ELEARNING IN COMPLEX SYSTEMS AND VEHICLE TELEMATICS

Laura Farinetti, Alessandra Rasetti

Politecnico di Torino
Torino, Italy
{laura.farinetti, alessandra.rasetti}@polito.it

Abstract

ELearning can be considered as a complex system, and as such, well-known research on General System Theory can be applied to define a model able to guide the design and production of more comprehensive and complex eLearning experiences. The paper applies the main principles of systems thinking to define an eLearning design framework and, starting from these principles, defines a number of guidelines for the design and the production of Autonomous Learning Objects (ALOs). Finally, the paper describes how the model has been applied in two concrete situations. The first experiment resulted in a prototype where the Autonomous Learning Objects are interactive video lectures organized and made available according to the systemic approach. The second experiment, developed in the context of the EADIS project ("European Automotive Digital Innovation Studio", funded by the European Commission under the Leonardo programme) shows how the model can be easily and quickly adapted to other requirements and different eLearning material.

Keywords - ELearning, Web based learning, General System Theory, Case studies.

1 INTRODUCTION

Most frequently eLearning experiences tend to reproduce the traditional face-to-face learning model: the introduction of information and communication technologies changes the surface but does not really impact on the essence of the learning process or on eLearning potentialities [1].

Recently new scenarios are emerging with new e-learning modalities supported by Web 2.0 languages and tools [2]. New distance learning researches and theories are growing with the name of eLearning 2 where the main items are the social dimension of Internet and the share of knowledge.

The emphasis is no more on Learning Management Systems (LMS) but on Person Learning Environment with Internet as a natural place for the development of collective intelligence [3]. "A form of universally distributed intelligence, constantly enhanced, coordinated in real time, and resulting in the effective mobilization of skills... No one knows everything, everyone knows something" [4].

Learning theories changed too, moving from a teacher oriented model to a student oriented model, from the transmission and accumulation of knowledge to collaborative learning. The formal learning is replaced by informal learning, intrinsically linked to the individual's everyday life and experience.

Theories on complex systems developed in last century's Sixties have been applied in various disciplines: the study of physics, biology, the immune system, but also in economy, language, science and communications.

Internet today, with new developments in Web2.0, can be considered as a complex open system: besides eLearning, which finds the Web as the natural application environment, can find in the theories of complex systems a new development model that involves both the technologies and the training models.

The idea behind this research is that eLearning can be considered as a complex system, and as such, well-known research on General System Theory can be applied to define a model able to guide the design and production of more comprehensive and complex eLearning experiences.

2 THE SYSTEMIC APPROACH

General System Theory (GST) was introduced by Von Bertalanffy in the Fifties. The word “system” comes from the Greek word "synhistanai," from which we also get "synthesize," meaning "to place together." Fritjof Capra, the founder of the Center for Ecoliteracy in California, defines a *system* as "an integrated whole whose essential properties arise from the relationships between its parts. (…) Systemic understanding literally means putting things in a context and establishing the nature of their relationships. In the Twentieth Century science the holistic perspective has become known as *systemic* and the way of thinking it implies as *systems thinking* [5].

“System is a set of interacting or interdependent entities, real or abstract, forming an integrated whole. The word *set* implies that the units have some common properties. These common properties are essential if the units are to interact or have relationships. The state of each unit is constrained by, conditioned by, or dependent on the state of the other units. The units are coupled. Moreover, there is at least one measure of the sum of its units which is larger than the sum of that measure of its units [6].

Accordingly “a complex system is any system featuring a large number of interacting components (agents, processes, etc.) whose aggregate activity is nonlinear (not derivable from the summations of the activity of individual components) and typically exhibits hierarchical self-organization under selective pressures” [7].

Systemic science introduces the fundamental concept of open system that the classical science ignored considering only closed systems. In a closed system matter and energy cannot be exchanged, while in an open system there is interaction and exchange of matter and energy. The theory of complexity starts from the concept that in nature there are no closed systems. Except for the universe, isolated systems are only abstractions: each real system is contained in another system, that is a subsystem. In other words, only one huge system exists, the universe [8].

Capra described six principles of ecological and complex systems. Each of these properties has to be understood and acknowledged in systems-level thinking. The six principles are:

1. Self-organization.
2. Edge of chaos.
3. Unpredictability, indeterminism.
4. Interconnection.
5. Circular causality.
6. Try & learn approach .

The principles are not watertight compartments, but are entities that often overlap, intersect and complement each other.

Self-organization

An open system exchanges energy and matter with the external environment, and avoids degradation and chaos. The self-organization and the non-equilibrium generate order, complexity and then life.

In the real world, atoms and molecules are almost never left to themselves, or at least not entirely: they are always exposed to a certain amount of energy and matter flowing into them from outside. In a limited area, the system can spontaneously organize themselves into a whole series of complex structures [9].

Edge of chaos

Complex systems are on the edge between order and disorder: too static or too chaotic, highly risky, always in delicate balance between creation and destruction. Between these two extremes, on the edge of chaos, should be the complexity, a sort of liquid state between too order and too disorder. One is for control and conservation and the other one is for revolution and anarchy. One is in favor of closing on itself and the other one is in favour of transferring information and communication [8].

Unpredictability, indeterminism

Theory of complexity discovered that any system, although simple and obedient to the deterministic mechanics laws of Newton can manifest unpredictably complicated and chaotic behavior, thus escaping control and prediction [9].

Interconnections

"A careful analysis of the process of observation in atomic physics has shown that the subatomic particles have no meaning as isolated entities, but can only be understood as interconnections between the preparation of an experiment and the subsequent measurement. Quantum theory thus reveals a basic oneness of the universe. It shows that we cannot decompose the world into independently existing smallest units. As we penetrate into matter, nature does not show us any isolated 'basic building blocks', but rather appears as a complicated web of relations between the various parts of the whole" [10].

Circular causality

Chaos theory teaches us that the direct linearity simply does not exist: linearity is an artificial way of viewing the world. "The reality is not a series of interrelated events that follow one another like beads of a necklace. Life is a series of combinations in which an event may determine the subsequent events in a totally unpredictable and sometimes devastating" [11].

Try & learn approach

A being living learns to develop and evolves while learning.

3 THE SYSTEMIC APPROACH TO DEFINE AN ELEARNING DESIGN FRAMEWORK

Traditional eLearning systems, with their tendency to reproduce the outline of the classroom lesson into a rigid and closed technology environment, is very far from the idea of complex systems. To propose a distance learning model similar to a complex system, the six principles of complexity can be applied to eLearning concepts.

For each principle implications for eLearning are identified, with the consciousness that the theory of complexity cannot provide absolute or foolproof recipes, but rather a way of looking at principles and problems under a different angle. The six principles are translated into:

1. Self-organization -> Self-organized learning.
2. Edge of chaos -> Creative learning.
3. Unpredictability, indeterminism -> Learning flexibility.
4. Interconnectedness -> Knowledge network.
5. Circular causality -> Virtuous circles.
6. Try & learn approach -> Exploratory learning.

Self-organized learning and Virtuous circles

Web 2.0 tools lead users to self-learning. The auto-organization can be individual or in groups of students who collaborate and cooperate in the learning process. The goal is not leaving absolute freedom to students, but to foster an environment where they can self-organize their activities to learn. The goal is to create a distributed knowledge within the system, where the nodes are the student's intelligence and connections are represented by dialogue and sharing. In this way the cooperative learning is encouraged through the informal learning inside an open environment that fosters contents sharing and dialogue on the issues. This is possible using the tools offered by Web 2.0 that allow the students to upload their own contents and comments into the system. Students with their intellectual

contributions become the fundamental elements of the system: they're able to self-organize generating bottom-up processes.

Creative learning and Knowledge network

One of the causes of the possible failure of eLearning experiences is the use of too formal learning models, where the lack of human contact has exaggerated the rigidity of educational content, of technology environments and then of student learning. In the same way using only methods of informal learning can create situations of anarchy and bring the education system into chaos and "disintegration".

It's at the edge of chaos that living organisms live, evolve, create and innovate. Therefore, also a teaching model must propose an appropriate balance between formal and informal learning to fit the edge of chaos. For this reason it is important to provide educational content organized and structured and at the same time encourage students to explore other information outside the system and, in turn, to share and enter in the system itself.

Learning flexibility and Exploratory learning

In eLearning closed systems, the educational path is forced into a linear sequence of materials. Also the Learning Objects (LOs) are designed to use in a linear fashion, where each unit of content is preparatory to the next one. LOs are designed as individual and independent units, but each LO contains information present in other LOs that, if explored, can contribute to a better understanding.

By creating connections between LOs we obtain a system of content available not only in linear mode, but also in networking, promoting a flexible and exploratory learning. The path through the course is unpredictable, but open to trial and even mistakes, stimulating informal learning in addition to formal learning. This new point of view changes the design process of the LOs and the result is a new content organized in what we named Autonomous Learning Objects (ALOs). Fig. 1 shows the differences between the LO and ALO concepts.

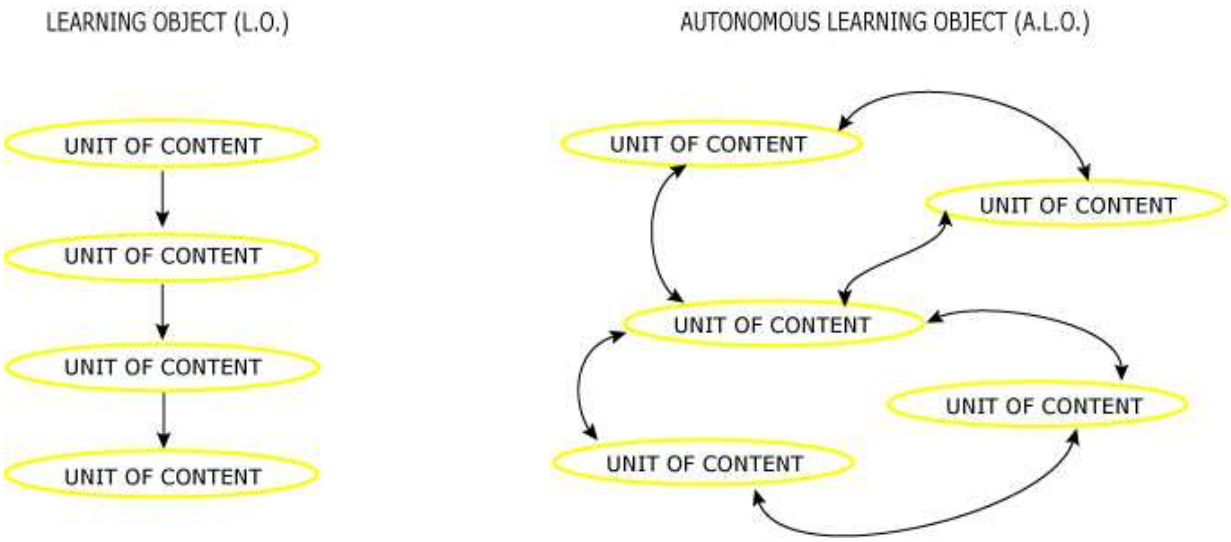

Fig. 1 – Learning Objects and Autonomous Learning Objects connections.

4 DEFINITION OF DESIGN GUIDELINES FOR EDUCATIONAL MATERIALS

Starting from the six principles, guidelines are proposed for designing and organizing educational materials. These guidelines, listed in the following, aim at defining a model for online learning systems.

1. Discretization of educational material

The first step is to deconstruct the didactic materials in ALOs, units of minimal content. The ALOs are autonomous and independent. We called this process “discretization”, because it transforms the flow of concepts into a set of discontinuous separated elements, extracted from sequences of narrative discourse.

2. Node highlights

Within each ALO the conceptual elements which are units of information are identified. We call these “nodes” and they must be a conceptual blocks of sense.

3. Hierarchy of nodes

Nodes can be classified into: training aids, deepening items and keywords. The information contained in a node can be from different media such as text, images, sounds and movies.

Training aids are contents that support the ALO, deepening items are supplementary contents like bibliography or teachers’ biography and keywords are nodes that describe ALOs common item.

Each node has a synthetic title.

4. Relationship highlights

Finally, authors should identify connections and relationships between the different units through the nodes.

5 APPLICATION AND VERIFICATION OF GUIDELINES

The guidelines have been applied and verified in two concrete situations, described in the following subsections.

The first experiment resulted in a prototype where the Autonomous Learning Objects are interactive video lectures organized and made available according to the systemic approach.

The second experiment, developed in the context of the EADIS project (“European Automotive Digital Innovation Studio”, funded by the European Commission under the Leonardo Programme) shows how the model can be easily and quickly adapted to other requirements and different eLearning material.

5.1 System Design course at Politecnico di Torino.

The first experiment consisted in designing and implementing learning model prototype to support a System Design course at the Industrial Design Faculty of Politecnico di Torino, whose main goal was to exploit the complex system’s characteristics and functions.

The specific project purpose was to apply the guidelines and obtain ALOs that respect the six principles of complexity applied to distance learning.

The model uses systemic ALOs in relationship with Web 2.0 tools, like video and image sharing, blog and network community. The model is able to give to students the possibility to integrate and upload different type of resources and to create a shared personal environment.

ALOs are based on interactive video lessons, organized according the systems principles. The interactive video technology is based on the associations of different contents into the video narrative line. Files like text, picture, audio and video can be associated to an exact and precise frame of the video. Also, an exact frame of the video can be associated to an exact frame of a different video. The result is a web of interactive videos where each video is an ALO enriched by student with Web 2.0 contents.

In turn students are organized in a web of relationship trough a social network: in this way the model is like an open complex system.

The videos in the prototype are eight lessons about systems thinking recorded during the System Design Master course at Politecnico di Torino in 2007. The lessons are:

- *The systemic view of life* by Fritjof Capra.
- *Insights in policy making to support system* by Anders Wijkman.
- *The logic of system design* by Gunter Pauli.
- *The power of system design* by Gunter Pauli.
- *What's innovation?* by Luigi Bistagnino.
- *La sostenibilità è un diritto* (English translation: *Sustainability is a right*) by Carlo Petrini.
- *L'ecodesign delle scienze gastronomiche* (English translation: *Ecodesign of gastronomic science*) by Carlo Petrini.
- *La sostenibilità nel consumo alimentare* (English translation: *Sustainability in food consumption*) by Carlo Petrini.

To apply the guidelines to the eight video lessons, we followed the methodological steps described below.

Discretization of didactic materials, nodes highlights and hierarchy of nodes

Each ALO is analyzed and deconstructed locating the nodes on the videos time line. The nodes are training aids, deepening items and keywords. (see Fig. 2 as an example).

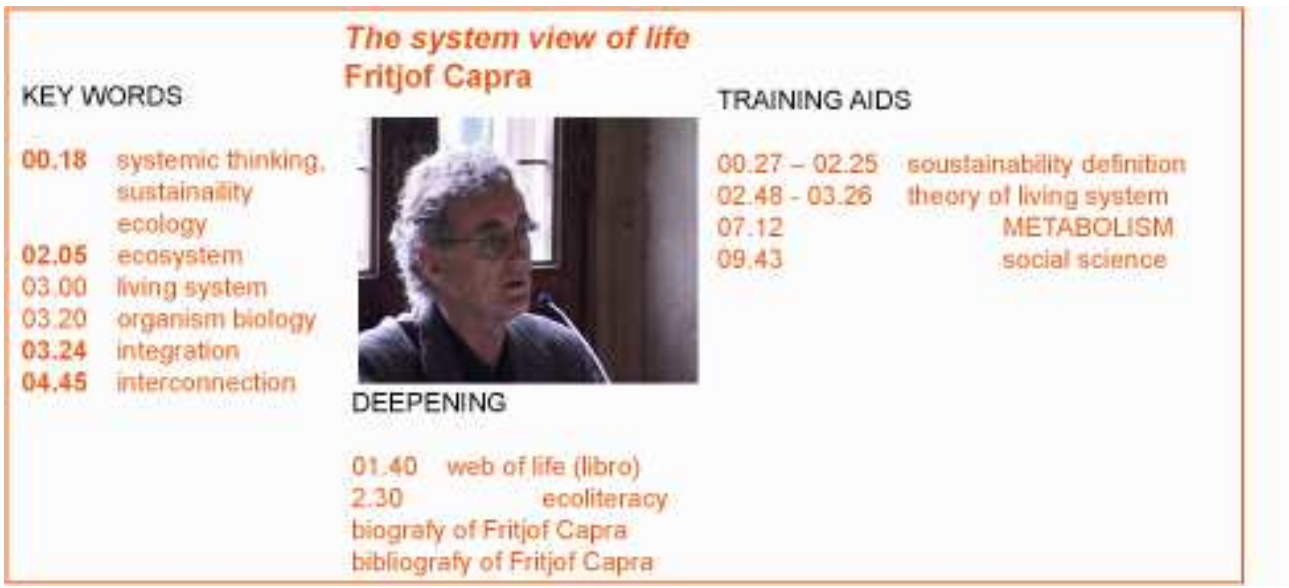

Fig. 2 – Example of discretization of didactic materials, nodes highlights and hierarchy of nodes.

Relationship highlights

Connections and relationships are identified between the nodes of different ALOs: see Fig. 3 as an example.

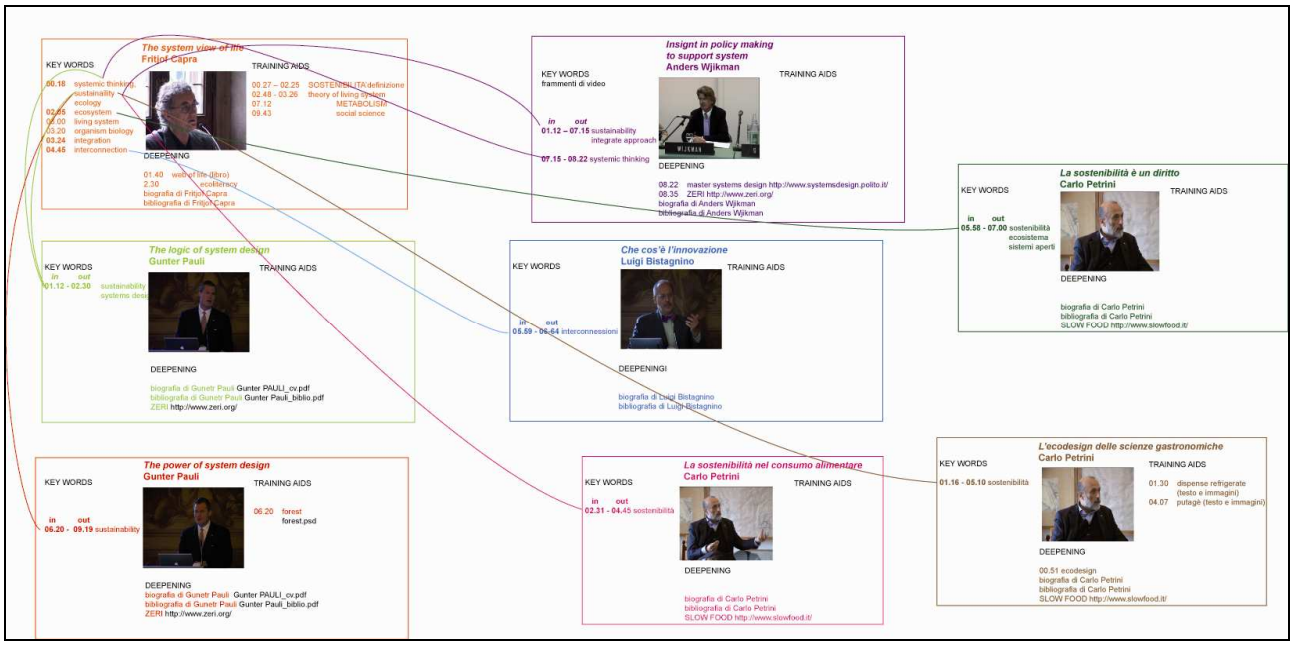

Fig. 3 – Connections and relationships between ALOs

The navigation structure of the implemented prototype is shows in Fig. 4.

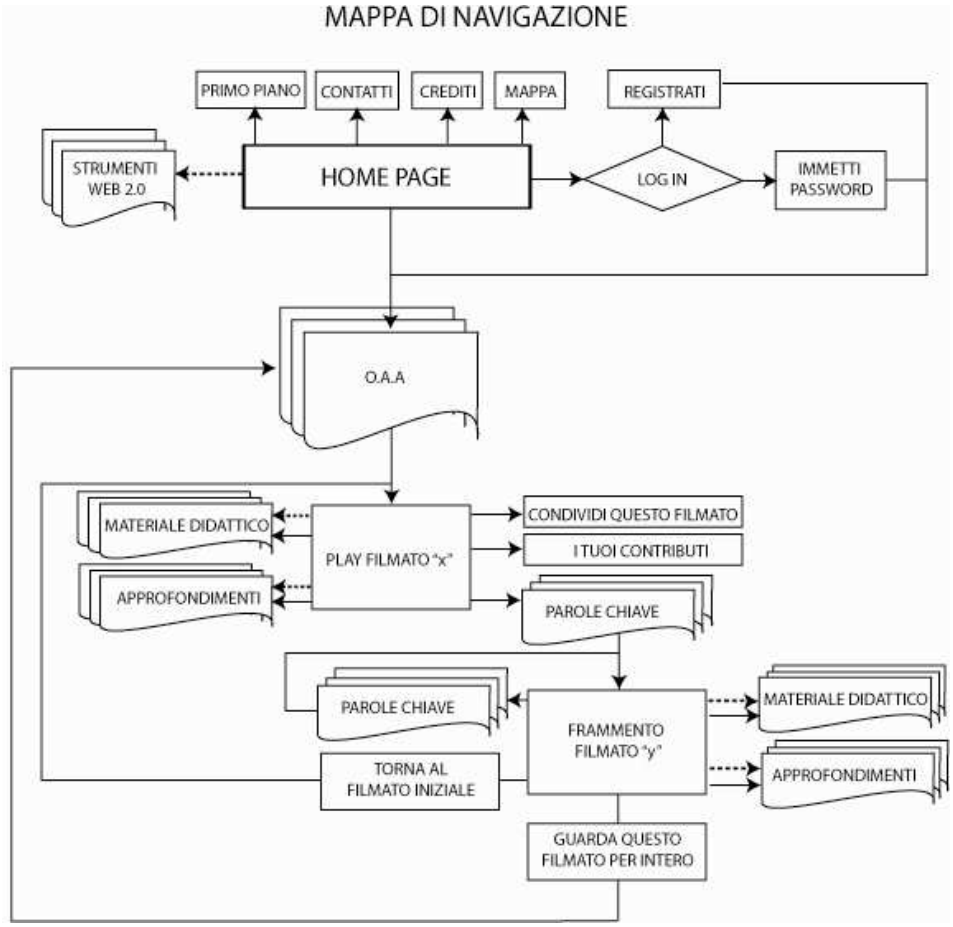

Fig. 4 – Prototype navigation map

All ALOs are visible and accessible from the home page to reproduce a non linear and flexible educational path: in this way the student is free to choose his or her own personal sequence of ALOs.

To access the students' network, users have to login with username and password.

The home page shows links to the main social bookmarking websites, a "news button" with the news about the Industrial Design Faculty of Politecnico di Torino, a "contact button" with e-mail address and a "credits button".

Each ALO contains a video lesson with links to training aids, deepening items and keywords. The ALO window contains also the link to the Web 2.0 tools to share the ALO with the rest of the Internet world and to add and upload comment and contributions.

The keyword links connect to fragments of video lessons belonging to other ALOs. This part of video has in turn links to training aids, deepening items and keywords.

About the layout study, ALOs are visualized as an interactive coloured tag cloud where the tags are the items of the ALOs (see Fig. 5 as an example).

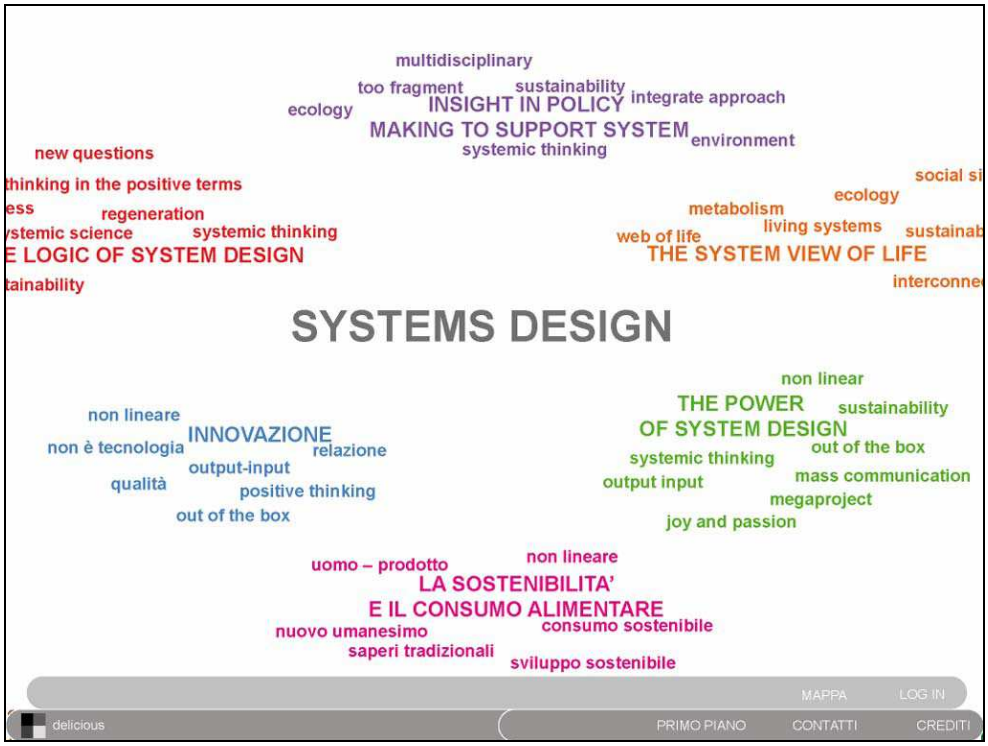

Fig. 5 – Interactive coloured tag cloud

By clicking on an ALO cloud item, a pop-up window appears with the video lesson. In the center of the pop-up window there's the video, on the right there are the training aids links and in the lower part there are deepening items. Finally, on the left there are the keyword links. On the time line of the video lesson appear the links to training aids, deepening items and keywords. Fig. 6 shows an example.

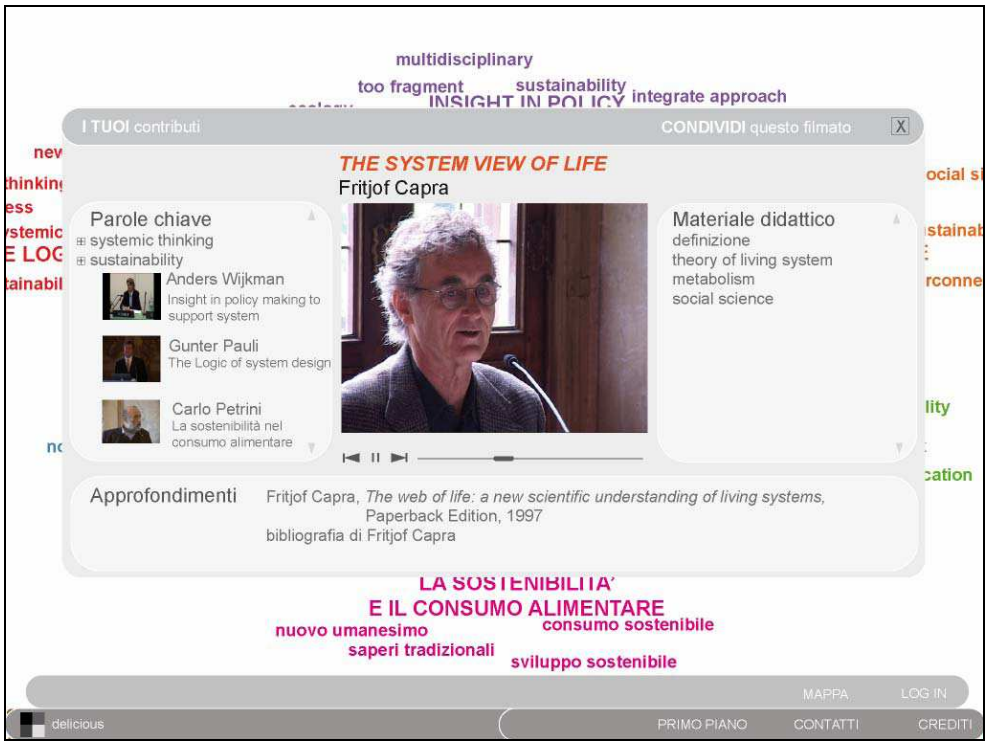

Fig. 6 – Video lesson with related links

By clicking on a key word a new pop-up window appears on top of the other, with a video fragment belonging to a different ALO. This new part of video has its own links to training aids, deepening items and key words. A button is also present to watch the entire video lesson. To return to the main video it is enough to close the current pop-up window. In Fig. 7 you can see an example of the new pop-up window.

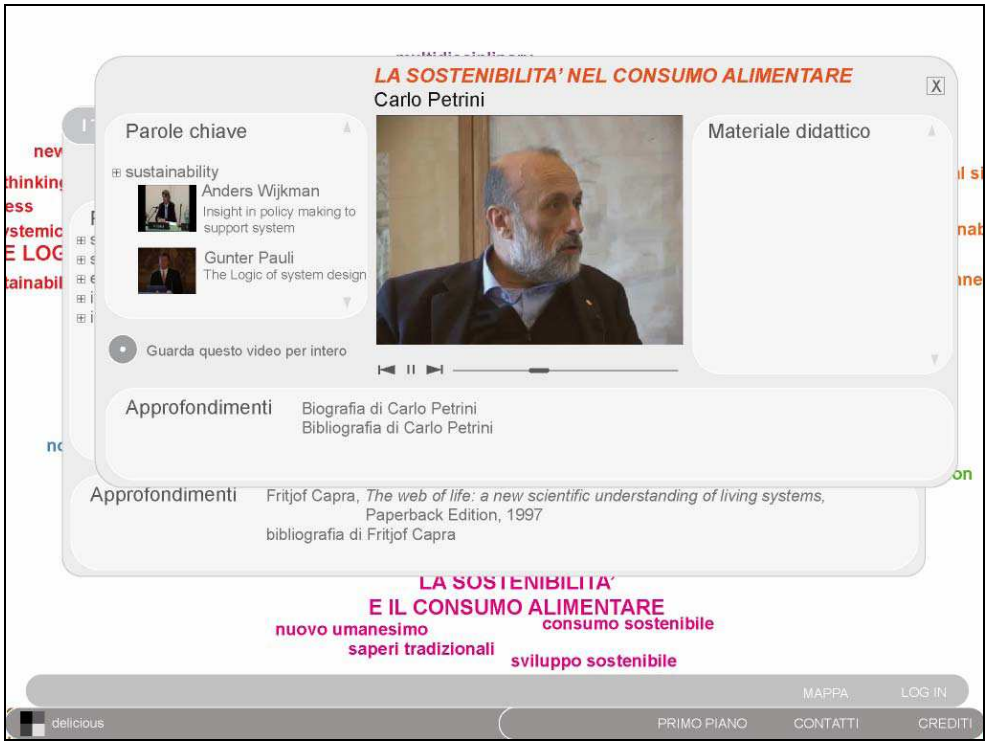

Fig. 7 – Pop-up window with related video fragment belonging to a different ALO

The prototype is implemented in Adobe Flash technology to obtain web product able to manage video in flexible and customizable mode.

The prototype has been used by Regione Piemonte, the institutional regional body of Piemont in Italy, to train its workers in a Lifelong Learning project.

The guidelines are been applied with the students of the Computer Science course in the Ecodesign degree course of Design Faculty at Politecnico di Torino.

5.2 Picture navigation skeleton for the EADIS eLearning environment

The second experiment consists in the design and the implementation of the prototype of a picture navigation skeleton for the European Automotive Digital Innovation Studio (EADIS) eLearning environment [9].

EADIS is a project sustained by the European Commission under its Leonardo Programme. EADIS will use a virtual work environment called the Digital Innovation Studio (DIS) to train professional designers in the automotive industry to deal with the impact and the application of 'vehicle telematics', to integrate new technologies into future products within the automotive industry.

This project is a partnership among Coventry University (UK), Oulu University of Applied Sciences (Finland), Munster University of Applied Sciences (Germany), Politecnico di Torino (Italy), and Technical University of Delft (the Netherlands).

The DIS is developed by Moodle software, a free and open source Virtual Learning Environment.

The specific purpose of our prototype was to organize pictures like a complex system by applying the proposed guidelines.

To apply the guidelines to the picture navigation tool, we followed the methodological steps described below.

Discretization of didactic materials and nodes highlights

Pictures are nodes and, in this case, the discretization and highlighting are not requested.

Hierarchy of nodes

Each node is classified with several key words. Each picture has got at least one key word in common with at least one other picture.

Relationship highlights

Connections and relationships are identified between the pictures through the nodes. Fig. 8 shows an example.

About navigation and layout, each picture contains key words linked to other picture. The key word link activates the related picture.

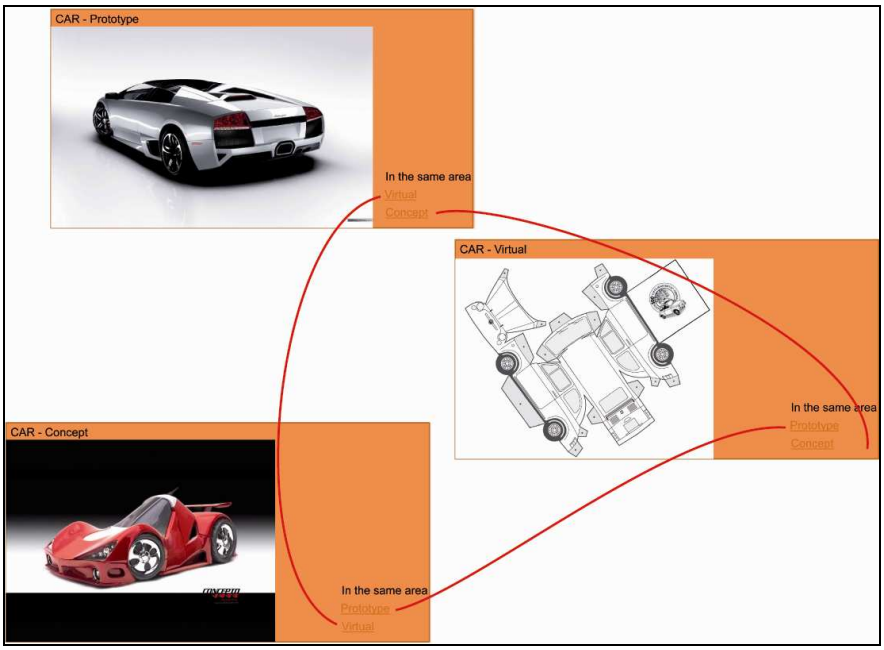

Fig. 8 – Connections and relationships between ALOs

The prototype is implemented with the Adobe Creator technology to obtain a simple and versatile visualization of pictures.

The prototype will be integrated in the DIS Moodle VLE.

6 CONCLUSIONS

The results of this research want to be a contribute to the actual debate about the future of eLearning with the object to lay the basis for a new share scenario.

The model studied in this research does not intend to be exhaustive and complete, but only a proposal and a starting point for new eLearning researches and developements.

References

[1] Gary Woodill, Where is the Learning in E-learning?; http://www.operitel.com/publication.aspx; http://www.zdnet.com.au/news/business/0,39023166,20266517,00.htm

[2] Tim O'Reilly, (2004). What Is Web 2.0 Design Patterns and Business Models for the Next Generation of Software; http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/whatis-web-20.html

[3] Scott Wilson, (2005), Future VLE - The Visual Version; http://www.cetis.ac.uk/members/scott/blogview?entry=20050125170206

[4] Pierre Lèvy, (1994). L'intelligence collettive. Pour une anthropoligie du cyberspace. Paris: La Découverte.

[5] Fritjof Capra, (1996). The Web of Life : A New Scientific Understanding of Living Systems, New York: Anchor Books.

[6] James G. Miller, (1965). Living Systems. In Behavioral Science, Volume 10, Issue 3, pages 193 – 237, John Wiley & Sons, Ltd.

[7] A. Drogoul and J. Ferber, (1994). Multi-agent simulation as a tool for modeling societies: application to social differentiation in ant colonies, Artificial Social Systems 830 (8).

[8] Silvio Cammarata, (1999). Complessità 2000. Un'odissea fra ordine e caos. Milano: Etas.

[9] Ilya Prigogine, (1996). La fin des certitudes: temps, chaos ed les lois de la nature. Paris: ÉDITION Odile Jacob.

[10] Fritjof Capra, (1975). The Tao of Physics: An Exploration of the Parallels Between Modern Physics and Eastern Mysticism. Berkeley, California: Shambhala Publications.

[11] R. Gibson, (1996). Rethinking the future: rethinking business, principles, competition, control & complexity, leadership, markets and the world. London: London e Naperville, Nicholas Brealey Publishing.

[12] The European Automotive Digital Innovation Studio (EADIS) Project, funded by the European Commission under the Leonardo Programme, online at http://www.eadis.eu/