Learning Objects and Semantic Web in Education: From Students' Analysis to New Perspectives for Their Use

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ABSTRACT

The work aims at giving a new perspective in ICT use in education by integrating web technologies in traditional teaching-learning processes. First it proposes the analysis of the difficulties students meet while attending both traditional and on line courses, then the factors influencing students' performances are discussed and alternative assessment instruments based on ICT use are reported. At last recent hypotheses on the introduction of learning objects and semantic Web in education are analyzed and e-learning strategies and instruments are compared with the results from traditional teaching contexts. As a consequence an adaptive e-learning strategy is suggested.

Keywords: Learning difficulties, Learning Object, Meaningful learning, Semantic Web, Teaching planning, Unit of Learning.

INTRODUCTION

Didactics and the disciplines interested in teaching planning and carrying out, always devoted their attention to three different elements in the teaching-learning process:

a) topics to be learned from students and their order and organization,
b) teaching process and its phases,
c) subjects (usually students) the teaching action was planned for.

During last decades (mostly in the second half of twentieth century) cognitive, sense-motor and affective taxonomies were developed (Bloom 1956, Mialaret 1999) to better define the strategies didactical process had to be based on (i.e., analysis of pre-requisites, planning and carrying out of teaching, evaluation, assessment and feedback). The process was in fact hypothesized to be cyclic, due to the feed back from students which could induce the planning of recovering actions when the expected results were not attained (Nicholls & Nicholls, 1983).

Recently different elements, including the introduction of ICT instruments and strategies, intervened to modify the well settled teaching-learning processes in education; two among them are analyzed in a greater detail in what follows:

a) students' learning features and assessment when e-learning environments are used,
b) the development of new instruments, like learning objects (LO) and semantic Web, to support continuous education and lifelong learning and to improve high and advanced education.

ICT AND STUDENTS' LEARNING

During last decades educational research evidenced the presence of many problems and difficulties in students' learning and especially:

1) preconceptions, misconceptions, and mental schemes, leading students to wrong interpretation of phenomena (for a survey of the work produced in this field the site of the Meaningful Learning Research Group http://www.mlrg.org/ can be seen),
2) the possible dependence of students' performances from their learning styles,
3) the importance of alternative instruments (i.e. portfolios) in students' assessment due to the value that people's performances and competences have in knowledge society.

The increase in the amount of the information to be managed, the frequent use of ICT in teaching and education and the need for the monitoring of the teaching process induced many scholars to experiment special information systems for facing the above problems (Cartelli, 2005).

Preconceptions, Misconceptions, Mental Schemes, and ICT

Literature shows that wrong ideas can be interpreted in at least two different ways (Driver & Erickson, 1983): a) mental schemes, if only the coherence of people's ideas in the analysis of phenomena is considered (with no reference to scientific paradigms); b) preconceptions or misconceptions, when people's ideas are compared and evaluated with respect to right scientific paradigms.

Many studies (Cartelli, 2002) carried out all over the world with differently aged people (from students to workers, from professionals to teachers etc.) show that:

- wrong ideas can be found in almost all scientific disciplinary fields;
- a lot of strategies and instruments have been proposed to overcome the problems people meet, based or not on IT and ICT strategies, and adopting or not constructivist strategies (supported or not by ICT). Nevertheless the good results of those experiences rarely were compared with traditional teaching and never were systematically used in education or adopted on a large scale (nationally or internationally wide spread);
- some experiments report that wrong ideas can persist in students (also if they attended the special courses described above) when they are forced to face special situations.

As an example the author's experience in basic computer science (CS) courses is reported here. First of all some wrong ideas were detected while analyzing students' learning on: computer input/output, human-computer interaction (when a GUI was used), data storing and retrieving, basic operations with a mouse etc.; it was then hypothesized that an e-learning platform based on traditional teaching elements and continuously monitoring the didactic process could help students in overcoming the difficulties reported above, while being a powerful instrument for the management of teaching. The information system the author planned and carried out (Cartelli, 2003), very similar to an e-learning platform, had CMS and CSCLS features. Notably:

- a well structured knowledge tree for the topics to be taught/learned was used for the course,
- special auto-evaluation surveys, integrated with the course's pages were available to students (i.e., many questions easily accessible for students were planned, on the basis of the wrong ideas formerly detected),
- various communication areas implementing virtual environments for teachers/professors, tutors, and students were used (to improve communication),
- a system for the management of students' evaluation and assessment tests was made available to teachers,
- two functions for the analysis of the students' access to course materials and the use they made of the communication services were continuously accessible.

The system was experimented with two different sets of students and had positive results as regards the number of students passing ending examinations; there was in fact only 20% student loss, while more than 65% of the students had positive, if not excellent scores. At the end of the courses a deeper analysis of students' data showed unexpected results and some limits for the system: 1) many students still evidenced the presence of misconceptions (more than 43% of the universe); 2) the great amount of data generated by the second set of students (more than 300 subjects) made very difficult the continuous monitoring of the didactical process by means of the functions described above and could be analyzed only at the end of the course.

Meaningful Learning, Learning Styles, and ICT

It has to be noted that a unique definition of meaningful learning has not jet been found and at least two definitions are available. The former one, credited to Ausubel (1990), is based on the following statements: a) the logical meaningfulness of the topic to be learned; b) the presence in the topic to be studied of special knowledge elements making easier the insertion of new knowledge into previous knowledge; and c) motivation to learn. The latter definition credits Jonassen (1995) with the following statement: knowledge construction (internal and external negotiation), context (meaningful and authentic environment), and cooperation (among students and teachers) are the basic elements for the definition of an environment leading to meaningful learning (which is active, constructive, cooperative, intentional, conversational, and reflexive).

Also under the hypothesis of both the above definitions, little or no dependence has been shown between the students' meaningful learning of topics and their performances at ending examinations, neither in traditional contexts nor in virtual environments and online courses.

Recently some studies have been carried out on the possible dependence of students' success on their learning styles (in distance education and e-learning courses).

First Kovacic and Green (2004) report of significant differences in the performances they registered in different learners' types in a computer concepts class. The authors identified the students requiring additional learning support for passing examinations and used the Felder-Silverman model for the detection of their learning styles. After the evaluation and classification of the students' learning styles according to the model they found statistically significant differences in their performances – that is, students with reflective, sensing, verbal, and global learning preferences had the best performances both in in-course assessment and in final examination. The authors explained this result with the vantage the learners received from current teaching styles and from the learning environment (course material and online students' support).

Other scholars (Kumar, Kumar & Smart, 2004) used pre- and post-tests based on the Grasha-Riechman Student Learning Styles Scale (another model for the analysis of students' learning styles) on a sample of 65 students (both graduate and undergraduate). They compared the number and types of learning styles at the beginning and at the end of the course and found relevant changes in the their distribution. For the authors the observed changes were due to the instructional strategies and to the technologies they adopted in the class (i.e., the use of collaborative projects and course management software increased the number of collaborative, participant, and independent learning styles among students).

Students' Assessment and ICT

Knowledge society and lifelong learning require a more efficient evaluation of the knowledge and skill people develop both while attending courses and while integrating out-school experiences into formal education. The portfolio of competences, one of the instruments recently developed, has had a great success in certifying students' success in educational activities (i.e., people acquisition of good skills and competences). There has also been a significant increase in the number of online portfolios at different levels of education; they tend in fact to combine the benefits of traditional portfolio-based assessment with the paper-saving and other benefits of online environments.

Love and Cooper (2004), while investigating the key factors for the design of information systems for online portfolio-based assessment identified four weaknesses: 1) design mostly omit key educational and administrative issues while focusing on technical aspects; 2) "online portfolios" are often made only of a single essay, a project report or presented as a Web-based electronic facsimile of a conventional document; 3) many designs for online portfolio are based on an over-narrow view of value distribution and do not take all stakeholders into account; and 4) designing of online portfolio assessment systems are often not well integrated with overall course design processes.

As a conclusion online portfolio systems feel significantly short of their potential, and in many cases are inferior to conventional portfolio assessment and other more traditional assessment approaches.

TEACHING, LEARNING OBJECTS AND SEMANTIC WEB

Learning Objects (LOs) were firstly introduced for their adaptation and reuse features and are nowadays experimenting new interest for their possible insertion in traditional teaching; new didactical proposals introduce teaching strategies in LOs' structure (i.e., a learner centered teaching activity is hypothesized). In such a way LOs can be used in schools and university and not only in contexts of lifelong learning (Fini & Vanni, 2005).

The new hypotheses for LOs' structure and use neither cancel nor modify the problems until now evidenced for them: a) the lack of a clear and shared definition of LO and the different models and standards until now proposed for them, b) the doubts on the pedagogical neutrality of LOs and on their reusability (depending for some authors on the pedagogical aims of didactical actions and for others on the educational contexts they are referred to).

Furthermore Semantic Web is even more seen as a valid instrument supporting teachers' work and reducing everyday workload.

From LOs to UOLs

Some scholars recently hypothesized the application of learning theory ideas to the planning and using of LOs in constructivist and collaborative teaching-learning contexts; in other words the construction of learner-centered or community-centered environments strongly based on the use of LOs was hypothesized (Fini & Vanni, 2005).

The hitting of the above target was performed with the inclusion into the LO model of the planning strategies guiding its choice and use (Alvino & Sarti, 2004). As a consequence LO structure was extended to contain the tacit knowledge and the meta-cognition depending on the adopted materials and reusability laid no more on the adopted materials but on the ways they were used for (i.e., LO becomes very similar to a "best practice" rather than a "piece of content" to be recombined with other content elements).

The theoretical change emerging from the above hypotheses induced R. Koper (2001) to propose a new language, called EML (Educational Modeling Language) and very similar to UML and XML, for the definition and description of teaching/ learning environments. The EML language doesn't manage LOs, its basic elements are called UOLs (Units of Learning), each UOL describing learning activities and all elements involved in the teaching/ learning process (i.e., the actors such as teachers, students, tutors etc. and materials, learning environments etc.).

Koper's work aimed at the construction of conceptual models for teaching/learning activities, letting people completely describe them in a formal way, adapt them to any pedagogical model, use them for supporting collaborative work and personalize them on the basis of students' prerequisites; the same conceptual models could also manage the collection of students' data and portfolios while respecting usual defined standards.

EML has been accepted from the Global Learning Consortium IMS and is know called IMS Learning Design (LD). It aims at the reusability of teaching/learning activities (i.e. templates to adapt to different situations or teaching experiences to re-produce).

Role and Function of the Semantic Web in Education

The basic idea of the semantic web, as stated from Tim Berners-Lee, is relatively straightforward: to create a layer on the existing web enabling advanced automatic processing of the web content, so that data can be shared and processed both by humans and software.

This declared result is obtained through the use of Resource Description Framework (RDF)-related technologies but there are also many other technologies for the creation of semantics. Some among them are reported below (Koper, 2004):

1. Unified Modeling Language (UML), providing a collection of models and graphs for the description of the structural and behavioral semantics of complex information systems,

2. XML and XML Schemas, to structure data and documents according to personal or community defined vocabularies (within which semantics can be implemented),
3. RDF and RDF-Schema, the metadata approach from the W3C, defining semantic meaning for data on the web (i.e., multiple semantic perspectives of the same data are possible),
4. Topic Maps, defining arbitrarily complex semantic knowledge structures and allowing the exchange of information for collaboratively building and maintaining of indexes of knowledge,
5. OWL – Ontology Web Language, implementing the semantic description of a domain by means of the specification of its concepts and relationships,
6. Latent Semantic Analysis, based on the use of programs for the understanding of natural language,
7. Software Agents, rather ill-defined, but commonly identified as pieces of software acting proactively (they are adaptive and (semi-) autonomous and can communicate with other agents and human creators).

An important question, strictly related to the educational semantic web, is concerned with the representation of a course in a formal, semantic way, so that it can be interpreted and manipulated by computers as well as humans. R. Koper (2001) refers to this process in terms of 'Educational Modeling'. He also states that Educational Modeling can be useful to solve (all or parts of) the following problems: development of flexible web-based courses (adaptable to learner features), preservation and sharing of knowledge on effective learning design, instantiation of e-learning courses in Learning Management Systems (LMSs), development of software agents supporting learners and staff in managing the workflow of activities, adaptation of didactical materials to individual learner's features (automatically driven by the descriptions of the conditions for adaptation), sharing and re-use of (all or parts of) e-learning courses, creation of more advanced and complex (but consistent) learning design and, at last, performing research into more effective and efficient learning design.

CONCLUSION AND FUTURE TRENDS

LOs and Semantic Web have had useful and interesting applications in continuous education, adult education and lifelong learning so that many authors suggested their application in traditional education, i.e. school and university.

The use of UOLs and EML by R. Koper can be seen as an example for the introduction of social-constructivist pedagogical approaches and different teaching models (active, learner-centered and community-centered) in educational practices supported by ICT.

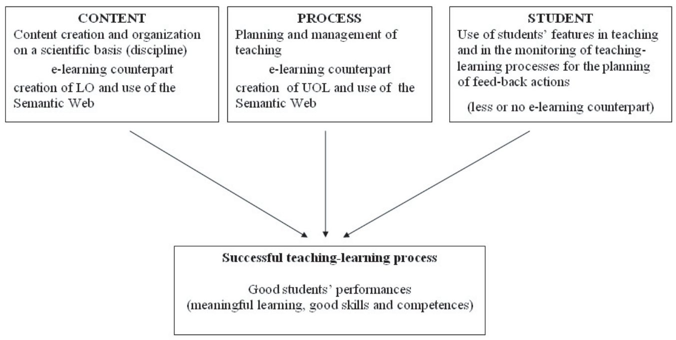
If everything seems to sound good there is, in the author opinion, an obstacle for the hitting of the target of a successful teaching by means of ICT in the above projects: it is the underlying presence of positivistic and deterministic ideas in all hypotheses formerly reported. In the projects involving ICT use in education the determinism is implicitly included in the optimistic idea that the right management of topics and discipline contents and the right control of teaching-learning processes can guarantee an efficient and meaningful learning in students. Otherwise stated the planning of special and well defined LOs, also made under the consideration of the right dependencies from other topics (which can be other LOs or more complex structures like the ones in the semantic Web) and when inserted in the processes of knowledge construction performed by one or more ULO (which can be individually or socially planned), do not guarantee, in the author's opinion, the students' acquisition of the right knowledge, skills and competences.

If e-learning aims at exiting from the important but limited field of lifelong learning and adult education, to become an essential element of school education (also in the limited hypothesis of integration of ICT into traditional educational processes), it cannot ignore the results of traditional teaching. Two key phenomena must be especially managed:

a) the introduction of feed-back and recovery actions in teaching processes governed by ICT,
b) the support to strategies helping students to overcome their difficulties and to acquire a meaningful learning.

A comparison between traditional teaching activities and their possible implementations by means of ICT can be useful to better understand the problems described above.

Figure 1. Elements affecting teaching-learning process and their e-learning counterparts



In figure 1 it is reported a comparison between traditional teaching and e-learning and in the last box it clearly appears the lack of adequate instruments and strategies in e-learning contexts.

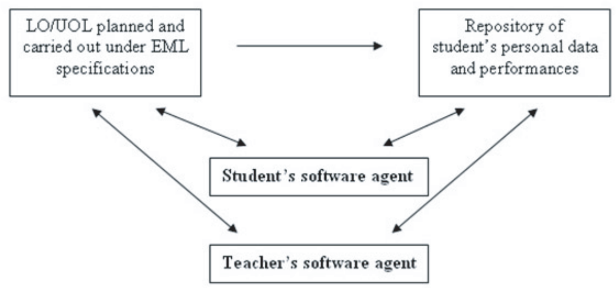
The lack of contact points between traditional teaching and e-learning in the last box is neither synonymous of the ICT exclusion from the corresponding processes, nor means that there is no experience or research involving its use. As reported in the first section of the paper there are many examples of studies collecting data on:

a) students' features and their modifications during the interaction with discipline topics in real and virtual environments;
b) students' messages, opinions and answers in forums, surveys and e-discussion instruments,
c) impact of e-learning strategies on students' learning and performances.

As a consequence it can be hypothesized the presence of the following scenarios for the integration of ICT in teaching:

- for the purists of learning objects theory and/or semantic Web there are at least two solutions (both depending or not on teachers' support to students' work and strongly based on a careful analysis of teaching-learning process): a) the need for special LOs and/or UOLs the student must interact with, when he/she does not succeed in hitting the target of a teaching action based on former different LOs/UOLs, b) a more complex structure for usual LOs and/or UOLs, which must have within them the functions for the analysis of students' learning styles (and other features), the functions to evaluate teaching action, the planning of recovering and support actions (when the right targets are not attained) and further learning materials and actions to be used for the recovering work,
- for artificial intelligent scientists the proposal of special systems, very similar for their structure to the well known ITS (Intelligent Tutoring Systems) or ICAIS (Intelligent Computer Assisted Instruction Systems), could better answer to the need of controlling the teaching-learning action and in helping students to improve their performances (main problem with this hypothesis is the presence of the same mechanistic hypotheses supporting the first solutions),
- at last an intermediate and adaptive solution can be proposed. It is based on the following three elements: LOs and/or UOLs and their semantic representations, repositories of students' data and software agents (respectively for students and teachers). It has the main advantage, in the author's opinion, that it doesn't lay on mechanistic ideas and gives new value and functions to teachers and educational research. Its main features are:
  - student's software agent collects student's data and stores them in a repository, furthermore, when the student interacts with the e-learning course, it transmit them to the LO/UOL,
  - the teacher's software agent proposes the student's case history to the teacher while suggesting possible didactical routes for the student; soon after teacher's choices are transmitted to the student's repository so that student's software can better guide him/her in the interaction with e-learning materials

Figure 2. Model of the adaptive teaching-learning process as hypothesized in third option



- data coming from student interaction with course materials and the results of evaluation and assessment are respectively transmitted to the teacher's and student's repository.

In the first case the teacher has good elements for planning possible recovering actions, in the second case the student's portfolio and the panorama of student's features can be completed. Figure 2 synthesizes the process described above.

Further elements making the third proposal useful for the integration of e-learning instruments in traditional teaching are:

a) notwithstanding the great deal of study and research carried out until now there is no definite and complete map for all factors influencing/conditioning students' learning,
b) it is not known if it will be ever possible to completely determine all factors influencing students' performances and learning, because of the dependence of these factors from the environment and the learning context (as an example it has to be remembered the case of computer science misconceptions: wrong ideas manifested from students have changed with the time, due to the introduction of GUIs).

A serious consideration of the above statements is fundamental for the individualization of students' learning and for the reduction of teaching automation in e-learning experiences.

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