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EDUONTO: AN ONTOLOGY FOR EDUCATIONAL ASSESSMENT

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The search for possible applications in the field of Education, by means of domain specific ontologies on the issues of assessment of learning (assessment) and system (evaluation), has been implemented through the construction, testing and evolution of an integrated learning environment called EduOntoWiki. It is supported by ontological structures related to science education based on active consent of specific communities of practice. It allows selecting and incorporating the ontologies in order to organize learning objects to improve learning process. It is created as a setting in which they had the relevant formal descriptions (coding ontology) and informal (and narrative contextualization of concepts); where the possible intra-and inter-community relations were made explicit and recognized by all participants through specific social software. The last point in particular, has led to our hypothesis: only the transition from a technology-driven model (formal, static) to a community-driven model (dynamic and integrated in an

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open learning environment) could make really effective and relevant the ontologies that we built in several communities of practice. Therefore, the final goal was the realization of an integrated learning environment attempting the difficult transition from an "ontological-formal" system to an "ontological-relational" one.

1 Introduction

The recent studies about forms of learning supported by education and learning technology state that the content organization and the construction of knowledge representation are increasingly directing towards a socio-constructivist view of knowledge in which learning is considered a collaborative act based more on social interaction and negotiation of meanings than the linear transmission.

Terms, such as web ontology, communities of practice, learning objects and metadata, that includes the sense of doing e-training today, are becoming more and more important. The importance of ontologies is now recognised in different fields of disciplinary research: there are ontologies in various domains ranging from linguistics to biology and in particular areas such as e-learning (Stutt & Motta, 2004; Naeve *et al.*, 2006) and educational contexts (Aroyo & Dicheva, 2004; Koper & Olivier, 2004; Galliani *et al.*, 2004). Ontologies, in a nutshell, are knowledge structures shared, negotiated and formalized by the scientific community (Studer *et al.*, 1998) through semantic description languages.

The ontological structure reflects the shared conceptual nuclei and aims to integrate the formal size of a domain of knowledge with the daily practice of relational different communities of practice and learning. They are, substantially, support environments of knowledge representation: they define and organize the key concepts of a specific domain of knowledge and, subsequently, they dynamically interconnect them each other by means of semantic relationships. Conceptual formalized networks are qualified as mediators of a knowledge field complexity.

The search for possible applications in the field of Education lingered on the construction of domain specific ontologies on the issues of assessment of learning (assessment) and system (evaluation).

The term *educational evaluation* is often used without paying attention to the main question: what is it? Is it a "social practice" in education? Is it a "discipline" with its own scientific statute having epistemological and methodological options able to lead activities in different application contexts including the educational one? Over and above the claim of primogeniture for which the evaluation was born in educational and school boundary as a practice or a theory of the measure, with no doubt, it reveals a "multidisciplinary"

nature because it needs more methodological and ontological contributes and a "trans-disciplinary" nature (Stame, 2000) because it has the feature of producing judgments and giving values to all the fields of the man behaviours. To make a rigorous concept from the idea of the evaluation we have to consider an initial definition allowing us observing and analysing procedures that are "able to evaluate". We shall characterizing the activity of the evaluation and giving a definition that move the problem to its pedagogical usefulness.

The observation and analysis of these procedures say that the evaluation is a way to express judges of human behaviours intentionally done to influence behaviours of other people. In the social sciences, among many definitions of evaluation, Palumbo (2001) gave the best one because they allow doing a punctual comparison with the educational evaluation that is appropriate for human and pedagogical sciences. For the authors, this is a cognitive action aiming at a judgment on an activity (one or more coordinate actions) intentionally done or to do in order to create external effects, it is based on research activities on the social sciences and it follows rigorous and codified procedures.

We may adopt this definition with respect to the *object* (social programmes, preferably public, influencing third subjects and employing resources and tools), the *purposes* (giving judgments by using criteria for particular properties of the objects, of the decision makers, actuators, targets of the interventions), the *procedures* (giving judgments by means of comparisons and a clear-shareable-verifiable process using collection-elaboration-analysis of data as in the methodology of the social research).

By designing the scientific domain of the educational evaluation by means of a conceptual map (part of the regional educational ontology), we pointed out the polysemy of the theoretical descriptions and the "multi-referentiality" of the experience-based practices. In general, the evaluation, as said by Dewey (1939), is a cognitive activity that controls and verifies the "reflective thinking". It is combined with the phases of the empirical research from the observation of the reality to the emergency of the problem, from the construction of the hypothesis and their theoretical sustainability to their experimental verifying and control by means of the action in the concrete situation. Scriven (1982; 1994) restated that the "evaluation is the milestone of the scientific research". He defined "trans-disciplinary" this new science (as, for instance, the statistic, the logic, the computer science) because it is "specious" to the processes of study and elaboration of subjects related to other disciplines (among them, the pedagogy and the didactic). He transferred criteria, paradigms and models in this science by comparing and adjusting them for the new arisen investigation fields.

2 Method

In the research "Evaluation of experimental educational and docimologic research" (project PRIN 2009: "*Quality of research and scientific documentation in Pedagogical Sciences*") a path for the construction of an ontology on the concept of Educational Assessment related to human sciences domain started. The investigation, which has led to the development and use of ontologies within communities of practice/learning, is born by the questions posed by two crucial emerging issues and among them intrinsically interrelated: the management and exchange of information (information overload) and the processes of collaborative construction of knowledge (Galliani, 2009).

The aim of the research was to co-construct and experience an integrated learning environment called *EduOntoWiki* for providing an effective tool of consultation, discussion and learning to academic communities, schools and other education institutions. How to create ontologies typically structured according to a top-down orientation or engineering-oriented, is the work of a small number of disciplinary experts that formalize the ontologies to spread to a wider community.

This approach tends to exclude the possible users not only in the process of creating but also, equally importantly, reviewing, editing, and including new concepts. For this reason, it was designed a development environment based on the possibility of activating processes to promote the sharing of meanings, making them easier not only among members of the scientific community/ academic but also among those who employ and practise daily the theories and concepts of domain knowledge related to evaluation (teachers, trainers, experts).

To achieve this goal the choice of a software wiki-based was crucial because the wiki interface is now a simpler and effective tool to allow a community, even inexperienced in advanced technological interfaces, to build knowledge in collaborative and dialogical mode (Souzis, 2005). So the construction of ontology is configured as a light-weight ontology where relations among concepts were considered not too bound to hard logical limits as happens in heavy-weight ontologies.

It should be emphasized that the search path has been more complex than the one used in exact sciences. Human science experts, in fact, do not always share the same categorizations and interpretations of knowledge and the meanings of key terms of those disciplines, making difficult or sometimes impossible their formalization. The terms used in the context of a community is in fact a real shared repertoire (Wenger, 1998) in the sense that the meaning construction arises from the interaction of two complementary processes: participation and reification. The last one, in particular, is used to create artefacts, symbols

and terminology that constitute the basis for participative and constructive activity. It is precisely this community aspect that has assumed importance in formalizing ontology: defining a domain of knowledge means creating a shared vocabulary that describes the concepts and relations among them.

EduOntoWiki was born as a project aimed at the realization of a Learning Object Repository with an ontological basis and it is made available on the Web: in this way, we tried to combine the most innovative and current instances at a national and international level related to e-learning and Semantic Web.

EduOntowiki is the first result of a long research and experimentation process for the fine tuning of a software environment able to manage in an easy and efficient way, the creation, the modify and the discussion on ontological structures from a user community coming from both the academic and work worlds. All the users may register themselves and receive personal username and password to be identified. All the users have the same permissions to create information their workspace and share it with the community. The community itself has to evaluate what the users create and share. However, there is an administrator for technical issues.

The users may access to different sections and activate functions depending of what they would like to do (Fig. 1): they may explore the last inserted topics, look at the sheets of the other users, the last experiences, books and other objects.

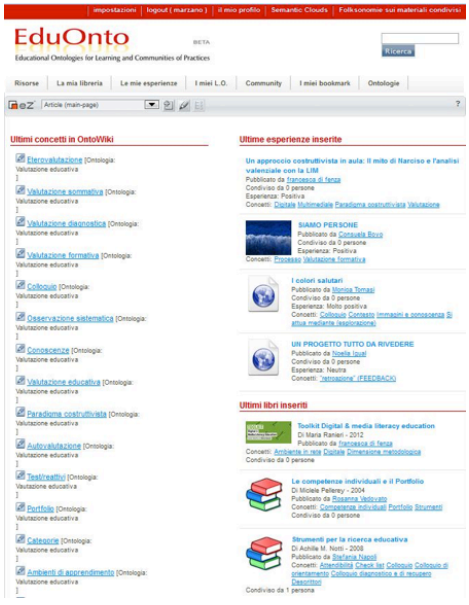

Fig. 1 - the sections of EduOntoWiki

EduOntowiki allows a set of functionalities able to support consulting and modifying of concepts of the ontology by using a Wiki-Based approach (Bao & Honavar, 2004; Schaffert *et al.*, 2005; Buffa *et al.*, 2008). It is possible to explore the concepts of the ontology from both the visual (Fig. 2) and the textual (Fig. 3) representations.

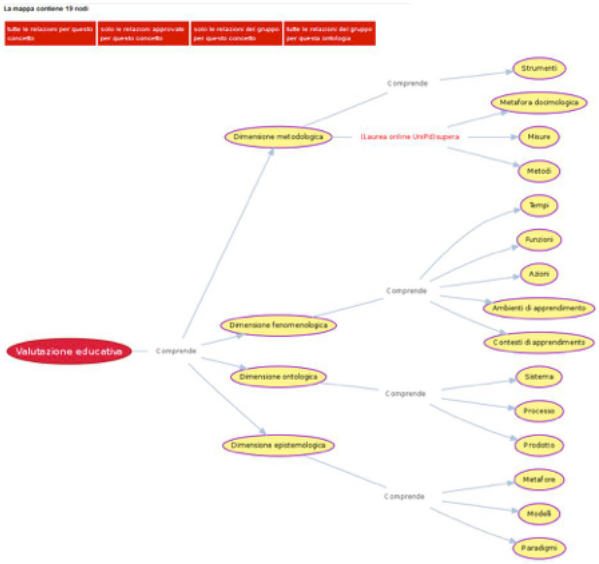

Fig. 2 - the visual representation

Web ontologies facilitates the interpretability of the web content, considered as a clarification of a particular field of the human knowledge. At the base of the research, there is a dynamic conception of knowledge; in human sciences the building of knowledge does not happen through linear paths and an axiomatic formal logic, but is in a continuous process of re/discovery, exploration, processing, re/conceptualization, dialectical interpretation of phenomena and events which occur in space and time.

Both scientific and practice communities, therefore, have a fundamental role in the development of ontology, by exchanging and comparing formal knowledge (the so-called *know duct*) and the silent knowledge (the empirical knowledge arising from contexts, experiences, beliefs, etc.). Ontology, in this sense, becomes a cognitive tool able to re/organize a disciplinary rule favouring the reflexivity of the experience in a virtual multi-referential environment, a place of dialogue and discussion/meeting between the scientific world and the world of experience/professional practice.

The biggest difficulties were identified to distinguish the fundamental concepts of ontology from other key terms related to real-world experiential contexts that have inevitably required the support of external academic practices (Ure *et al.*, 2007). From a theoretical point of view, this approach is very close to the situated cognition theory, where real life contexts (Brown *et al.*, 1989) help the knowledge acquisition, by considering where, when and how it was brought.

Fig. 3 - the textual representation

We considered the descriptions of these contexts in the ontology by creating a folksonomy, a taxonomy that is defined by rejecting the traditional rigid and inflexible classification systems (Mathes, 2004).

The typical reticular structure of Web information led us to consider related criteria in which the most important rule to adopt was the pragmatic, concrete context. This approach, in our view, efficiently allows managing those concepts frequently subjected to re/trading practice/learning communities.

The ontology construction happened with the support of the program *Mindmanager* (and the similar free software *Freemind*) and has been subsequently moved online in an environment designed to hold and develop web ontology (EduOnto), including a social network environment, where the teaching practices are linkable to theoretical constructs of Educational Assessment domain.

The ontology on educational evaluation was organized considering five different interpretative components that characterize teaching science by relocating from each of these higher order key concepts, from which other concepts of lower order expand themselves hierarchically.

All the key concepts of the domain concerned were organized on the following dimensions (Fig. 1):

- epistemological, about scientific paradigms and theories related to the domain of educational assessment;
- referential, concerning pluralism objects which deals with educational assessment;
- methodological, on methods, techniques and tools of measurement and evaluation;
- phenomenological, relating to educational and social real places where evaluation actions (from formal contexts environments) implement
- axiological, about reflections on educational and social values.

From each of the five dimensions (Fig. 4) the concepts of higher order (type) were identified from which other concepts of hierarchically lower order (tokens), more specific and less general expand. The choices made in the construction of hierarchical mind map reflect the multi-referential epistemological viewpoint of a scientific community of researchers and experts, which justifies the categorical order through relations of ontology, whose arguments are primarily considered cultural mediations with communities of practice/learning users/users.

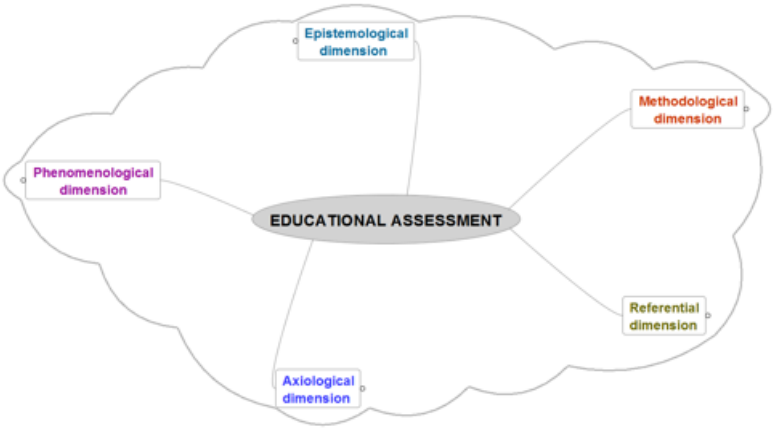

Fig. 4: Graphical representation of Educational Assessment

The concepts identified and the corresponding hierarchical relationships were inserted into virtual environment *EduOntoWiki*. Ontology created in the environment *EduOntoWiki* took the form of a particular map at the same time conceptual and hierarchical, dynamic and navigable. Every concept proposed

in it has a short definition that supports, through the wiki, possible definitions with processes of negotiation and sharing of meanings between participants. Each concept has been linked to citations drawn from national and international literature that allows us studying the concept in order to go beyond the mere definition. An additional level of depth of understanding comes through the connection between concepts and references. Fig. 5 shows a portion of the map relative to the *referential dimension* hierarchy.

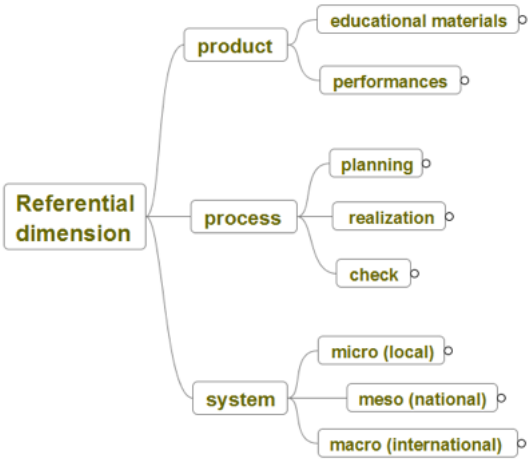

Fig. 5: Graphical representation of referential dimension

Starting from building a collection of ontologies that describe actors, processes and technologies in the human sciences we has also tried to verify if the main problems of learning objects, the pedagogical dimension and consensus terminology in the metadata, could be solved through the development and the use of appropriate domain ontologies. Then we proceeded to the mapping of the contents and the design of learning units. For each instructional objective tied to a learning object, the objects of contents (content objects) have been defined and the relations among them have been identified by adding them to the navigation on the educational evaluation ontology. All these operations were carried out by referring to the link among metadata and underneath ontological structures.

Another goal of the research was testing the effectiveness of ontology as a support tool for the development of higher cognitive processes (if it was possible to achieve positive results in terms of learning through the use of alternative methodologies, such as those provided by the web, in the form of ontologies and learning object). The use of such facilities, in the form of con-

ceptual maps is adequate to support learning and self-regulation mechanisms under the activated processes.

Next to the development and implementation of Educational Evaluation Ontology, we proceeded to define and implement an experimentation protocol to investigate and verify on the ground, considering the objectives of the research, whether and how the ontological structure was able to provide appropriate tools to support, on the one hand, a dynamic process through which lexicons and meanings are negotiated and re-negotiated and on the other, to encourage reflection on the cognitive processes underlying learning in order to consolidate the associative, comparative and analysis capacity as well as the skills of self-regulation and monitoring of actions. From the results emerged from a first experimentation ended in September 2008 (Notti, 2009), in the 2010/11 academic year we started the verification of ontology using an experimental protocol held at the Department of educational sciences of the University of Salerno; we have identified a sample of students (204 students divided into 4 groups: a control consisting of 101 students; three experimental for a total of 103 students) attending the degree course in Science of Education.

Students belonging to the Control Group have done course activity (for a total of 15 hours) according to a traditional methodology: lecture, use of multimedia presentations, discussions. Students in the experimental group (divided into three subgroups related to the number of media stations available in the computer labs of the Department) have undertaken, each individual, a self-training course aimed at the acquisition of knowledge by learning object, conceptual maps, Ontologies and semantic clouds.

The arguments in the platform concerned actors, processes and technologies in the educational sciences. In particular, concept maps, viewed by students, were in the domain of knowledge on the Educational Evaluation. Four meetings were dedicated to self-learning with each experimental group (for a total of 12 hours). In addition, we carried out a lesson in the classroom for a discussion on the topic of verification (evidence of profit) lasted two hours.

During the experimentation, we carried out a systematic observation of the most frequent activities of participants using a structured Protocol with which we have been able to record in detail the different behaviours and relevant aspects of this formative experience online.

We pointed out the observation categories and, for each of them, we formulated the indicators able to represent behaviours and their intensity. The units to use are in the following:

- The *space*: the physical place (in terms of human and instrumental resources) where the learning activity happens and that have influenced the learners during their experimentation. The multimedia laboratory has been the place.

- The *participants*: the actors in the space.
- The *activities*: the actions of the actors in the scene.
- The *groups*: the modalities adopted by the students to create groups and share their learning paths.
- The *management processes*: how the tutors supported the learning experiences.
- The *notes*: observations and notes to records accident and unexpected events during the learning activities.

3 Discussion

All the students received a test on 30 items. The results of the students of the experimental group (EG) and the control group (CG) were rather homogeneous and qualitatively equivalent. Despite the differences in the paths, we have found positive results in all groups and this confirms the effectiveness of the learning path and results more than satisfactory in terms of quality of learning. To grasp the significance of the data, we defined some relevant indexes by means of statistical process. The defined indexes are:

- The arithmetic media (Ma);
- The median value (Me);
- The standard deviation (σ);
- The coefficient of variation (CV).

The following table (Tab. 1) will bring the results.

Table 1
DESCRIPTIVE STATISTICS

	Ma	Me	σ	CV
EG	21.52	22.20	2.30	0.11
CG	22.02	21.90	3.22	0.15

The values of standard deviation and the coefficient of variation indicate a high level of homogeneity of scores and a breakdown of responses almost symmetrically centered on the media value. The values of arithmetic media and median are equivalent.

From the analysis of data emerges as the formalization and representation of knowledge supported by ontological environment has encouraged the reorganization of knowledge acquired, bringing to reflect on their own mental models. The proposed training activities supported by the ontological environment, they also allowed the actors to read again and re-conceptualize their knowledge

(Le Boterf, 2000) considering the theoretical reference and conceptual schema proposed with the ontology.

The data collected through the questionnaire given ex post to 103 students in the experimental group have allowed detecting the perception of effectiveness of ontological environment to support individual study. Specifically, the recognized elements as facilitators and mediators of the complexity of scientific educational assessment domain can be traceable: the graphical representation that supports and provides a summary of the complexity of the domain; active participation; complex and relational dimension of knowledge; the recognition of ontology as a product of a collective intelligence; the study of key concepts related to the scientific domain.

Conclusion

As part of the research project "*Learning objects and ontological structure: development and analysis of methodologies for the use of Learning objects inserted inside of domain ontologies*" we started a path for the construction of an ontology on the concept of Educational Evaluation on assessment of learning (assessment) and system (evaluation).

The aim is to investigate the semantic web applications in the educational contexts and training by integrating the most innovative and current instances relating to e-learning and the Semantic Web by co-construction and testing of an integrated learning environment for the purpose of providing an effective tool of consultation, comparison and learning to academic communities, schools and other educational institutions. The described approach represents a point of departure to create integrated environment for the educational evaluation where different methodologies and models may live together in order to automatically create efficient and effective assessment systems as stated in (Miranda *et al.*, 2013).

The research has been realized through the construction, experimentation and evolution of an environment called *EduOntoWiki*.

Indeed, the experimental research provides results that corroborate the spoken language based on conceptual maps we are discussing in this work. Definitely, the results of the present work provide the opportunity to plan future research activities. The first concerns the possibility of using mixed methodologies based on a series of actions and complementary tools. The second relates to the significant role that the educational use of concept maps can take: the challenge is to identify which training activities should be programmed to ensure that their use is not negative. Moreover, the evidences (provided by the results of this work) suggest that we could to further investigate non-linear communication models to face the assessment process by means of ontologies.

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