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Semantic Learning Narratives

An Investigation of the Usage of Semantic Web Technologies to Support Learning

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Abstract

This report is about the intersections between narrative hypermedia and semantic web technologies for eLearning. Although various research has enhanced the hypermedia field by making use of semantic web technologies, there is little work in order to pitch this approach to an educational perspective. Actual eLearning technologies, focusing on the definition and re-use of learning objects (LO), often sacrifice the expressiveness of the metadata descriptors to the reusability of a resource. This leads to shallow semantic annotations, and consequently, from a pedagogical point of view, to a poor sequencing of the learning objects. In the first part of this report, we want to help the reader contextualize this problem and realize how it can be solved through the usage of *domain ontologies*, describing the important concepts in an area, and *narrative ontologies*, describing the fundamental pathways within a semantic space. In the second part of this work, instead we show how the instantiation of these two dimensions within a specific domain, philosophy, will allow us firstly to develop an application to test these ideas, secondly to compare other similar approaches and look out for an abstract layer of learning narratives independent from any domain.

Introduction

Computers are everywhere, and the Internet is regarded as the most powerful communication device ever seen in human history. The Internet, in fact, makes a vast amount of information available, but does this really facilitate human capability to learn, or does it just open a large number of *cyber paths*, without giving a proper *map* in order to make sense of them?
A key-word search engine like Google can help us find a list of resources, connected merely by a *string* similarity, and, as we know, many times it fails in answering our initial research question. Of course this happens because a computer can hardly understand the sense of our words, but treats them only syntactically, namely, taking into account their external shape and not their meaning.
If the normal web we browse daily can be seen as a huge repository of this kind of "meaningless" information, the project of the semantic web consists of a meta layer built on top, in order to describe it and make it more meaningful to an automated agent. Therefore, it ideally points to a situation where all data comes together with the description of how to use it, a situation which would realize a web of knowledge and not only a web of information.
Given these premises, it is possible to go one step forward and imagine a semantic search, namely, a search action that is informed by this meta layer above the web and that points to resources in the web or in the real world. In such a scenario, it is possible to look for the name of a person, and retrieve only results that correspond to the class of entities classified as “people” within the semantic metadata. Furthermore, it is possible to perform some reasoning over the knowledge represented in the metadata, and retrieve results following some more complicated paths, in a way similar to the actual reasoning our minds perform.
While researchers are trying to find the most effective ways for *annotating* the "old" web, new perspectives are also emerging in the area of eLearning. In fact, in a scenario where resources are annotated and could be found on the web, instead of a normal search engine we could have an intelligent knowledge browser that, given a goal, follows some pre-existing knowledge patterns, gathering a set of resources that fulfil the goal. For example, I could ask this software agent to help me understand a specific concept in physics, and receive a series of knowledge elements that, properly digested, will bring me to the understanding of that concept. In other words, the knowledge browser bridges on-the-fly the missing spaces between what I already know and what I would like to know, giving me the opportunity to contextualize a piece of information and actually learn how to get there semantically.
In the first and main part of this report, in order to give some theoretical foundations to the vision above, we want to overview the existing literature in this new field of research, taking into account its being inherently multidisciplinary and, in particular, the role *narrative studies* have had in inspiring the approach we have chosen.
The second part, instead, will show how we intend to instantiate and test these ideas in a specific domain, philosophy. We will therefore outline the major dimensions along which it is possible to deploy a philosophical ontology, in order to semantically characterize different and distributed resources; we will finally present some initial ideas regarding how to create intelligent *learning narratives* out of the potential annotated material.

PART 1

LITERATURE REVIEW

1. Introduction

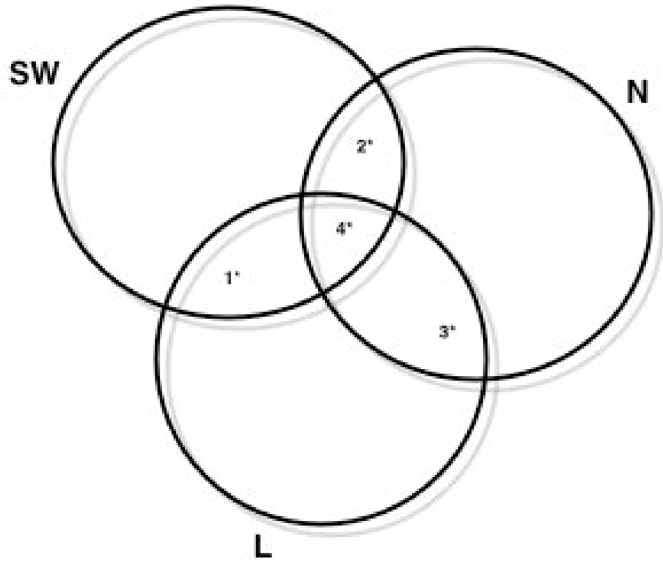

Figure 1 – The research space

The figure above, even if in a simplistic manner, represents the dimensions and the possible perspectives of this research. The focus, the place towards we are heading to is the crossway between three different areas: the Semantic Web, the Narrative theory, and the Learning Sciences. Each of these is a world on its own, and it does not necessarily encounters the other two, especially at the same time (zone 4*).
In fact, as we will see, there are attempts of conjugating the concept of narratives construction with the aim of supporting the learning experience, without caring about any specific technology (zone 3*); there are tools that benefit of new semantic web technologies in order to implement digital narratives, without paying attention to the pedagogical issues (zone 2*); or applications exists that even if employing the semantic web technologies within a learning perspective, do not take into account the potential of narratives (zone 1*).
Therefore, this research firstly intends to define the necessary intellectual tools in order to grasp the whole framework that forms and gives meaning to the new Semantic Web Education (SWED). Secondly, we will try to focus on this new area itself, with a particular emphasis on narratives, and draw some conclusions about:

a) The level of maturity that these technologies have reached,
b) The degree of discordance between the initial theories and practical necessities that have driven the development of these technologies, and their effective results,
c) The gaps left open for future research and experimentation.

As a final remark, it is important to remember that the implicit viewpoint adopted in analysing the literature benefits from its being grounded on a specific project, aimed at the instantiation of the ideas and technologies of the SWED. The specific domain we are taking into consideration is philosophy, and, broadly speaking, that part of the "noosphere" compounded by theories and organized perspectives on the world and the human existence (we will better explain these concepts on the second part of this work). In fact, the same analysis carried out on this domain could possibly be extended, with minor modifications, to any other academic discipline, since the definition of learning narratives we are pointing at should also produce an abstract framework (an *ontology*) which is utilizable in other scientific domains.

The following different sections, therefore, intend to give an account of the theoretical assumptions of learning and narratives (sections 2 and 4), the eLearning evolution and the most recent developments of this field (sections 3 and 5), and of the technologies emerged with the semantic web together with the first systems which employ them within an educational scenario (sections 6 and 7). Finally, the last chapter tries to summarize the main points of this route and specify a rationale for future research.

2. Learning Theories

The learning sciences are a wide field, drawing influences from an even wider set of disciplines and from the whole history of philosophical thought [1]. In this section, we do not want to give an exhaustive account of all the standpoints and the possible approaches, but just revisit some recent conceptions that have influenced the modern educational scenario, very much supported and at the same time determined by the usage of computers.
In particular, we will dwell upon the theories of cognitive apprenticeship, constructivism and collaborative learning.

Brown, Collins and Duguid [2] have done an inspiring work that compares the learning activity during normal apprenticeship and the one that happens within a scholastic environment. Usually, this difference is reduced to the difference between the categories "know how" and "know that". Nevertheless, they argue that this dualistic position is artificial, and that it should be overcome by a new epistemological standpoint. In fact, the activity in which knowledge is developed cannot be separated by its outcomes. Knowledge cannot be treated as an abstract entity and therefore it cannot be transferred as it was a material good. As they say:

> "For centuries, the epistemology that has guided educational practice has concentrated primarily on conceptual representation [...] An epistemology that begins with activity and perception, which are the first and foremost embedded in the world, may simply bypass the classical problem of reference - of mediating conceptual representations."

So, on the side of the traditional epistemology of "*possession*", limited to the exploration of the "know that", a new epistemology of "*practice*" [3] should develop and re-integrate the role of world and action in the knowledge generation process.
The notion of *context* is crucial in order to understand this position: the social and physical environment always influences the way knowledge is produced, so, in order to positively transfer knowledge, the same environment must be taken into account and used as a grounding for the learning process. As they say, knowledge is always *situated*.
The authors provide a series of compelling examples and case studies that prove this position, like some experiments on vocabulary teaching, in which students, although

given very precise definition of new words, would still have great difficulties in using them within normal conversations. The knowledge acquired, in fact, remains abstract and does not have any link to the possible context of usage. Even in the everyday language, indexical words (like *I*, *here*, *now*, *next*, *tomorrow*) show us that an important part of our meaningful utterances is strictly attached to the situation in which it is used.
Following this line, the conclusion reached by the authors is that conceptual knowledge is to be treated as a tool we use in everyday activity, and that the usage of these tools is encoded in the culture of a community. Effective learning is apprehending how to use these tools meaningfully, thus effective learning is basically a process of acculturation and experience sharing within a group of people.
The process in which conceptual knowledge is successfully used and put into practice is called by the authors *authentic activity*, and constitutes the only setting capable of generating a real learning experience.
The critique towards contemporary schooling is to be abstract, detached from real problems and unaware of the necessity of the students to engage with the relevant domain culture that has actually generated what is being taught. For example, the teaching of math as a formalistic set of rules and methods usable only within abstract scenarios leaves the subject unlinked to the real problems that started the research, and, moreover, encourages a culture of math phobia rather then one of authentic math activity.
Thus, as a generic practitioner during a practical work activity learns "socially" how to use a tool, the *environment* has to be central in the teaching of conceptual knowledge, has to ground the intellectual work and has to provide the application scenario of the knowledge generated.
Cognitive apprenticeship is the new category that describes a learning method based on social interaction and activity, in way similar to that evident in craft apprenticeship. For example, math teaching should be contextualized and linked to the problem solving activities that generates the abstract definitions and rules, and, similarly, philosophy teaching must be linked to the real word facts where the initial questioning begins.
The benefits of this approach are well described by the authors:

> "By beginning with a task embedded in a familiar activity, it shows the students the legitimacy of their implicit knowledge and its availability as scaffolding in apparently unfamiliar tasks. By pointing to different decompositions, it stresses that heuristics are not absolute, but assessed with respect to a particular task and that even algorithms can be assessed in this way. By allowing students to generate their own solution paths, it helps make them conscious, creative members of the culture of problem-solving mathematicians. And, in enculturating through this activity, they acquire some of the culture's tools--a shared vocabulary and the means to discuss, reflect upon, evaluate, and validate community procedures in a collaborative process."

These guidelines are very important in relation to the design of an eLearning application, since, as we will see, many times the computer has been used as a purely delivering device for instructional content, without keeping into consideration the (in this case passive) role of the learner, or the situation within which the learning activity happens. Having clear in mind the characteristics of cognitive apprenticeship leads to the realization of systems which help the user *extend* his/her knowledge, which build on what is already existing in the learner's mind, and let him/her construct autonomously specific learning routes, depending on the situation he/she is involved with.

Another approach that is complementary to the epistemology of learning is the one of constructivist theory, whose roots can be traced back to the works of Piaget [4, 5] and Bruner [6, 7] . This theory affirms that all knowledge is constructed and that is not the result of passive reception. Learning is an active process in which learners construct new ideas or concepts based upon their current or past knowledge. This approach stands in clear opposition to the one of a) realist (e.g. Platonic) theories, for it does not support the idea that there is a "true" nature of things that can be successfully reached through a pre-defined method, and of b) behaviorist (e.g. Skinnerian) theories, since it tries to model the learning experience from the inside and not only describe it empirically from the outside.
Within the constructivist framework, in fact, the learner and what is learnt are not treated as distinct entities, but they influence each other in a dialectic that generates the knowledge phenomena. Following a classification presented by Hein [8], we can enumerate some fundamental features of such an educational approach:

- Learning is an *active* process that requires the learner being engaged with the world.
- There are always two different levels in the learning process: while constructing meaning, we also construct *systems of meaning*. For example, if we learn the chronology of dates of a series of historical events, we are simultaneously learning the meaning of a chronology.
- *Language* has a central role in learning.
- Learning is a *social* activity: our learning is intimately associated with our connection with other human beings, our teachers, our peers, our family as well as casual acquaintances, including the people before us or next to us at the exhibit.
- Learning is *contextual*: we do not learn isolated facts and theories in some abstract ethereal land of the mind separate from the rest of our lives: we learn in relationship to what else we know, what we believe, our prejudices and our fears.
- One needs *knowledge to learn*: it is not possible to assimilate new knowledge without having some structure developed from previous knowledge to build on. The more we know, the more we can learn.
- *Motivation* is a key component in learning. Unless we know "the reasons why", we may not be very involved in using the knowledge that may be instilled in us, even by the most severe and direct teaching.

These are the principal traits of constructivist theory, even if various currents have contested and modified the initial approach of Piaget, highlighting one or the other single feature as the most important. However, for that regards our analysis, this short review lets us single out other key points that must be looked at while designing any software to support learning.

Another important and widely recognized field of research is collaborative learning (CL), since computers, being quite often used as integrated media for communication, have the potential to foster collaboration between people located in far-away environments. So, it becomes fundamental to theoretically define these types of interactions, in order to point out where the technology plays a distinctive role in a

'group' educative process, or where the collaborative learning differs from an individual learning.
A clear and useful description of this scenario is given by Dillenbourg [9], who first provides a high level definition of "collaborative learning", and then draws from it the fundamental directions of research:

> "The broadest (but unsatisfactory) definition of 'collaborative learning' is that it is a situation in which two or more people learn or attempt to learn something together".

Therefore, the elements that need further specification and that generate a variety of scales and combinations in CL situations are:

a) The <u>number</u> of people involved in the process, e.g. from small groups of 2-5 people to entire communities of thousands of people. In this respect, beyond the empirical differences of bigger or smaller CL settings, major importance is given to the choice of the underlying theories that guide the creation and the analysis of a specific setting. As the author says, "just as a photographer uses different lenses for photographing a flower or a mountain, scholars need different theoretical tools in order to grasp phenomena on various scales". So, for example, *distributed cognition theories* could be used to look at the group in a holistic manner, as a big cognitive system composed by various social and cognitive processes that extend the basic characteristics of an individual's cognitive processes. On the other hand, instead, scholars claim that the individual is already a distributed system, building on the idea that thinking is somehow a *dialogue with oneself* (an idea very old in the history of thought); thus, the studying of the way this internalized dialogue works and supports learning will also shed light on how groups should behave in order to learn effectively.
b) The way people <u>learn</u> in collaboration, e.g. they can study a course together, or perform some problem solving activity in cooperation. In this case, it is necessary to define the conditions that can trigger some learning mechanisms in individual cognitive systems: in fact, even within a group of peers, the learning process still happens at the *individual* level.
   It is interesting to see that these conditions that enable the learning process are a kind of *social contract* between the peers or between the peers and the teacher. As Dillenbourg says, "the words collaborative learning describe a situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms, but there is no guarantee that the expected interactions will actually occur". In order to control and direct these conditions towards the realization of a successful environment, we can work along four different dimensions:
   - Set up initial conditions, that is, carefully design the situation in order to increase the probability that some kind of interactions occur.
   - Over-specify the collaboration 'contract' with a *scenario* based on *roles*, namely, provide a strict *method* of interactions to the peers.
   - Reinforce interaction rules by encompassing them in the medium, for example, in computer-mediated collaboration, by providing 'semi-structured' interfaces that address learners towards productive interactions.
   - Monitor and regulate the interactions, thanks to the figure of a 'facilitator' that acts following a principle of minimal pedagogical intervention in order to redirect the group work in a productive direction.

c) The last dimension useful in describing a CL scenario is the kind of collaboration instituted between the different actors, e.g. computer mediated, synchronous or not, etc. Also in this case, there are four different constraints that can be examined to describe the degree of collaboration present in a learning process:
   - The situation can be more or less collaborative. This depends mainly on the degree of *symmetry* in the interaction, that is, to which extent peers are at the same level, in terms of action, knowledge and status; another criterion is the presence or not of common goals between agents, the degree to which they can negotiated in the process and maybe also revised; finally, a last constraint is the degree of division of labor among group members: e.g., in *cooperation* partners split the work, do it individually and then assemble the partial results into the final output, while in *collaboration* partners do the work 'together'.
   - The level of interaction itself brings along a degree of 'collaborativeness', which can theoretically be defined "not by the frequency of interactions, but by the extent to which these interactions influence the peers' cognitive processes". The interaction can therefore be synchronous (collaboration) or asynchronous (cooperation), may involve a wide space for negotiation (of views, opinions and even roles) or a narrow level of it.
   - The cognitive processes triggered imply more or less learning activity, e.g. concepts of *induction*, *conflict* or *cognitive load* can help in defining the group's learning behavior.
   - Finally, the effects of a CL can be investigated in order to define its validity, and usually this happens through some measurement of the individual pre-test / post-test gain with respect to task performance. However, specifies the author, CL is a process that involves so many different dimensions that it is very difficult to associate a positive (or negative) result to a single one of them. Moreover, even if these effects are often assessed at the individual level, it has been objected that a more valid assessment would be at the group level.

A theory of collaborative learning, says the author as a final remark, should pay attention primarily to the previous four aspects (situation, interactions, processes and effects). In addition to this, he highlights the fact that this area of research is and must remain strongly multidisciplinary (gathering hints and results from cognitive psychology, computer science, distributed artificial intelligence and linguistics, at least), and that, also if it usually focuses on the cognitive aspects of human collaboration, soon or later it will also have to deal with the social and affective aspects of this complex phenomena.

Finally, if it is to mention another activity that should be fostered and supported in education, that is critical thinking [10]. This is a quite advanced skill that is not easy to acquire and that is based on defeating "cognitive biases", prejudices and mental laziness. Through the studying of arguments and debates, students should in fact learn how to question any chosen standpoint and motivate it with valid reasons. For example, pointing out the linkages between concepts and theories within a domain (or across different domains), helps the student grasp the systemic trait of knowledge, namely the fact that every taken position is never isolated but instead it lives within a specific debate, in a net of relations within which it peculiarly obtains its meaning and

significance. Again, the notion of *context* is crucial since it pushes towards a way of thinking that is not passive but actively engaged in the sense making process.
In conclusion of this chapter, we must remind the reader that there are a number of other theories of learning that describe the process under different perspectives [11], however, cognitive apprenticeship, constructivism and collaborative learning are the ones that best describe the usage scenario of the technologies described in the following chapters.

3. eLearning

This section focuses on the usage of computers in educational environments, and, in particular, on the advancements this practice has achieved since the advent of the Internet and the World Wide Web. This change is represented by the victory of a dynamic and distributed paradigm on a centralized and static one, and by the utilization of more comprehensive theories (especially the one we have just examined) in order to understand and model this new *ubiquitous* learning process.

The importance of eLearning in the 21st century life has been repeatedly highlighted by Drucker [12]. He argues that the essence of eLearning relies on the tools and knowledge needed to perform work being moved to the workers, wherever and whoever they are. This *just-in-time education* becomes therefore strictly integrated with the high velocity value chains that characterize nowadays commerce, and basically moves the focus of education from the institution to the individual. The focus on the primary resources is moved as well: not anymore material goods or machines, but intellectual assets and human capital are the key factors that guarantee survival in this fast economy. Drucker, moreover, defines a list of modalities along which we can explain the difference between traditional training and eLearning (figure 2).
The two fundamental benefits of eLearning, he continues, are the eliminations of the barriers of time and distance and personalization of the user's experience. Apart from traditional academic education, also computer-based training and distance learning are bearers of an old paradigm, and will be overcome by a new one. Computer-based learning (CBT), in fact, although being essentially self-paced and user-friendly, is just an attempt to automate education and replace the instructor with some pre-recorded educational content. Distance learning, similarly, through the use of multimedia technologies and asynchronous interaction provides a richer and more personalized user experience, but its contents and methods are established for a general audience. The new eLearning, instead, augments the others because it is integrated into the value chain activity, that is, it integrates content in context, delivering the most timely form of knowledge.

	Training	e-Learning
Delivery	Push – Instructor Determines agenda	Pull – Student determines agenda
Responsiveness	Anticipatory – Assumes to know the problem	Reactionary – Responds to problem at hand
Access	Linear – Has defined progression of knowledge	Non-linear – Allows direct access to knowledge in whatever sequence makes sense to the situation at hand
Symmetry	Asymmetric – Training occurs as a separate activity	Symmetric – Learning occurs as an integrated activity
Modality	Discrete – Training takes place in dedicated chunks with defined starts and stops	Continuous – Learning runs in parallel and never stops
Authority	Centralized – Content is selected from a library of materials developed by the educators	Distributed – Content comes from the interaction of the participants as well as the educators
Personalization	Mass produced – Content must satisfy the needs of many	Personalized – Content is determined by the individual users need to know in orderto satisfy the needs of one.
Adaptivity	Static – Content and organization/taxonomy remains in their original authored form without regard to environmental changes	Dynamic – Content changes constantly through user input, experiences, new practices, business rules and heuristics.

Figure 2 - The learning paradigm shift (Drucker, 2000)

Another interesting analysis that frames the meaning and the usage of advanced eLearning techniques is given by Dillenbourg [13], who tries to explore theoretically the scope of usage of AI techniques in training software. Also if done more that ten years ago, this work is still important since it provides some hints about when and where to use them. Being not primarily relevant in education the “strong” aim of AI of reproducing human intelligence, it becomes more important the extent to which these techniques <u>support interactions</u> which are interesting from a pedagogical point of view. The author roughly discriminates three categories of learning goals: automatic skills, acquiring declarative knowledge and acquiring complex problem solving skills. Only the last one, he claims, can be supported by computer based learning environments. These ones, in fact, are conceived as systems representing open problem situations in which the learner can explore the consequences of his action, and construct step by step his knowledge. In conclusion, an AI enhanced eLearning system, by taking advantage of learner modelling techniques, pedagogical strategies and rule-based reasoning, should assist the user in the decision making process and in the reasoning process. In this way, it will eventually help turning the learner’s declarative knowledge into operational skills.
These suggestions clearly implement the idea of an eLearning environment that must be “situated”, in the sense explained by Cook and Brown. The interactions Dillenbourg’s system should support are the connection to the real world and the everyday experience that only will establish a real learning process.

The principles of constructivism presented in the previous section, instead, tend to remain abstract and far from the eLearning practice. However, some work has been done in order to instantiate them in real world scenarios. Karagiorgi and Symeou [14] stress the importance, for instruction designer, of understanding strengths and weaknesses of each learning theory, in order to optimize their use in educational strategies. The process of translating the philosophy of constructivism into actual practice is analysed along three different dimensions (corresponding to the three major phases of instructional design):

1) For that regards the analysis, the traditional approach is based on the definition of the conditions of the instructional systems, such as the content, the learner and the instructional setting; instead, considering the fact that there is not an ultimate truth and that objects and events do not have absolute meaning, the design task aims at creating an environment where *meaning is negotiated from a rich context*, and new ways of understanding can emerge. Thanks to an analysis of the learner's predispositions and "misconceptions", the context should also be structured in order to allow the learner recognize his false assumptions, build on them and start a process of "cognitive restructuring".
2) The traditional development phase is normally arranged as the gathering of a sequence of learning units in order to achieve specified performance objectives. Instantiating constructivism, instead, means to put learners at the centre of the instructional environment, let them struggle with problems of their own choice, and develop innovate ways to resolve them. The technology should provide learners with a "*phenomenarium*" (an artificial limited arena where phenomena to investigate occur) or with a "construction kit" (a set of modular parts with which to make things). These settings must reproduce the complexity of real world scenarios, where problems can occur under different circumstances and can also be solved using different strategies. This approach leads to a "*cognitive flexibility*" that stresses conceptual interrelatedness and links each solution to a particular context. Moreover, the creation of collaborative learning environments should also be fostered, in order to let the students compare multiple perspectives on an issue, and socially negotiate the meaning of an experience.
3) The evaluation phase, from a constructivist standpoint, is a delicate matter. In fact, it could be misleading to think that there is no single truth or pre-defined content to learn, since this position seems to lead to an 'anything goes' ending. We must remember that all the knot of solutions to a single problem are not arbitrary, but remain connected to and defined within an historical intellectual climate. Furthermore, the student's approach appears to be more important than the particular solution: evaluation should control the students' critical skills, their ability to explain and defend decisions, their meta-cognitive and self-reflective attitudes.

In conclusion, the two authors support the translation of constructivist theory into educational practices, also if they acknowledge the intrinsic challenge lying within this proposal, especially for instructional designers. This challenge may be overcome by the embracement of a "moderate constructivism" philosophy on instructional design, which keeps track of all the unavoidable difficulties of drawing links from theory to practice.

As introduced in the beginning, the Web has a primary role in the delivering of this just-in-time education, in fact a number of different web-based systems have grown with the aim of supporting the learning activity. Between them, the most common are the so-called courseware management systems (CMS), online environments that provide a wide set of functions for a virtual classroom, such as the sharing of learning material to read, programming examples to analyse, quizzes to take, tools for communications like chat-rooms or email services and others.

These systems, as Brusilovsky [15] argues, due their popularity mainly to one factor: their being versatile. In fact, the quite long research in AIED has produced systems that can provide better support to the learners, but that remain fragmented in respect to the educational activity considered as a whole. The author is referring mainly to intelligent tutoring systems (ITS) and adaptive hypermedia (AH), well known technologies which draw their force from the construction of a learner model and the definition of specific teaching behaviours depending on this model.
The potential of moving these types of systems into the new web-based environment is appealing, and can be justified at least by the two following reasons: firstly, the fact that since the users of a Web system would be many more compared to those of a traditional standalone application, a personalization of the service would become fundamental; secondly, the fact that the Web, leaving more autonomy to a learner (who often works not from the classroom but from home), at the same time falls in the assistance a teacher or a peer student can provide in a normal classroom.
Therefore, Brusilovsky and colleagues propose an innovative adaptive and intelligent Web-based educational system, ELM-ART, which aims at supporting more than one function at the same time, and aspires to be versatile enough to gain the users' approval. This is a system for the teaching of the LISP programming language which inherits from a previous on-site intelligent learning environment (ELM-PE) a series of features, such as example-based programming, intelligent analysis of problem solutions, and advanced testing and debugging facilities. All these characteristics rely on a representation of the domain knowledge (the LISP grammar) and of the episodic knowledge (linked to the performances about a particular learner).
However, in the *www* version of the system (that is available online at http://apsymac33.uni-trier.de:8080/Lisp-Course), these features are enriched by the fact of being easily accessible from any browser, in the form of adaptive hypertext lessons. If before it was not possible to run this system everywhere, for its complexity and the consequent need of very powerful machines, now any decentralized client can interact with it and generate a personalized learner model (which will be stored in the central database). Moreover, other features have been added, like some facilities for communication (chat, email), an open and editable student model (for comprehensive customization), a LISP interpreter with advanced visualization (to avoid the problem of installing the programming environment on different computers).
ELM-ART thus constitutes an illuminating example of <u>how an ITS can be redesigned and converted into a Web-based system</u>, and compete with all the functionalities of the more widely used CMSs.

A different summarization of the evolution of the area of instructional technologies is the one proposed by Koschmann [16], who follows a kuhnian approach and tries to identify a series of incommensurable paradigms underneath the theories that have motivated work in the field. Without going into the details of his analysis, it is interesting to note how he reckons the different paradigms have culminated in the computer supported collaborative learning one (CSCL).
According to this recent perspective, the focus must be on the use of technology as a mediational tool for collaborative methods of instruction. Of course, there is not a unique design for CSCL systems, since collaborative learning, as we have seen, may involve a vast range of interactions and situations. However, they can be basically categorized depending on the locus of use (intra, inter or extra classroom), on how the use is coordinated in time (synchronously, e.g. chat programs, or asynchronously, e.g. email), or on the instructional role they are designed to serve (to situate a learning

process, or to support problem solving). Thus, as Lipponen [17] says, CSCL is focused on "how collaborative learning supported by technology can enhance peer interaction and work in groups, and how collaboration and technology facilitate sharing and distributing of knowledge and expertise among community members".

Another attempt to cast the new Web-based instruction into a theoretical framework is presented by Young [18]. After pointing out how little research is present in order to understand "the unique ways in which the Web might promote, impede or fundamentally affect the way in which we learn and the development of related skills", the author goes one defining the new medium as a "*cognitive tool*". That is, a device that at the same time supports one's cognitive powers and receives its cultural significance and meaning by the community of users. This means that while we are helped in our learning and thinking from a Web-based activity, we are also determining the Web's 'normal' usage routines, which subsequently affect also the way it is further developed.
This dialectic between learner and tool is described using three theoretical positions: <u>situated cognition</u>, as we have seen, emphasizes authentic activity as the most fertile learning setting; <u>distributed cognition</u> theory posits that one does not possess knowledge as such, rather, "knowledge evolves from a complex relationship between the tools, rules, values, artefacts and individuals making up a particular environment"; <u>activity theory</u> studies cognition as the result of the learner's goal-oriented activities, the various tools used in these processes, the communities involved in the environment and the rules they have established. These theories should therefore be used as conceptual maps to understand the everyday use of the Web and to draw effective instructional routes based on the growing new technologies.
The work of Young, therefore, does not intend to be a conclusive assertion on the nature of web-based activities, but it opens diverse directions of research and stresses the importance of a theoretical reflection in order to drive and understand the practice.

Finally, in the field of eLearning theory, it is worth noting other research done in the following directions:

- The definition of some ethical guidelines for computer supported education [19], based on the fundamental dimensions of human beings. For example, systems should avoid information overload (intellectual dimension), should encourage and not demoralize the user, while supporting the developments of positive character traits (ethical dimension), or should not attempt to replace the teacher (social dimension).
- The definition of a "blended learning" paradigm [20], in which the advantages of traditional lecturing are conjugated with the repeatability of eLearning software. A complete and deeper form of learning is in fact reachable only if the 'human factor' is maintained within the educational process: in such a scenario, the burden of delivering significant parts of intellectual knowledge is allocated to the computer, while the teacher acts as a facilitator and a bearer of the human values to be transmitted to the student.
- The assessment of the added value of eLearning strategies on student's performances. If learning can be described (within the framework of Cognitive Load theory) as a passage of information from working memory to long-term memory, there are techniques to evaluate the frequency and success of this process and therefore estimate the design of a learning environment [21].

Other work has also been done in order to break down the eLearning constituents and establish criteria to evaluate a system [22].

3.1 Learning Objects and Standardization Issues

The distributed nature of the Web, and consequently the lack or central organized repositories for digital resources, has led to the creation of *descriptors* in order to foster exchange and re-use between these resources. In the case of educational resources, the notion of "learning object" has been developed in order to frame the basic independent units usable in a learning activity. A learning object is defined as any entity (digital or non-digital) that may be used for learning, education or training, composed by a content and a set of descriptors. These last ones, usually called *metadata*, should apply to learning objects in order to describe their salient features, and facilitate their exchange.
In particular, in a scenario like the one described by Devedzic [22], metadata are used to fill the gap between *educational servers* (repositories of educational content generated by the authors) and *clients* (which could be learners, or other authors). In this scenario *pedagogical agents* are web services that are able to reason on the metadata of the resources, collect them in a variety of ways (for example following pedagogical, personalized or collaborative schemas) and present them to the user within a final formatting.

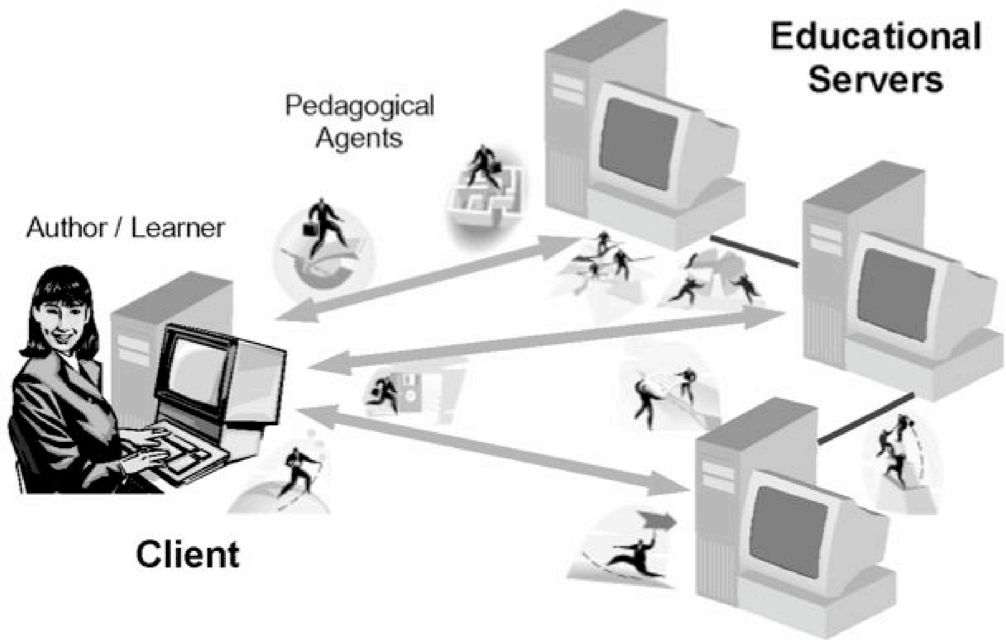

Figure 3 – The future learning scenario (Devedzic, 2003)

It is crucial for the agents (human or digital) that metadata are defined using the same semantic structure, or that at least different metadata schemas are compatible between themselves. This is in fact the core problem of learning resources' exchange, and in general of any communicative activity on the Web: the sharing of a language, i.e., of a formal protocol that also machines can interpret. In order to address this issue, different organizations have started a number of projects to define an international standard, but, as we will explain below, this approach, besides not having succeeded yet, carries also some implicit limitations, due to the nature of the metadata languages used. We will now go through the principal attempts to solve the standardization issue, describing briefly for each of them the salient features.

- The Dublin Core Metadata Initiative (DCMI) [23] is an open forum engaged in the development of interoperable online metadata standards that support a broad range of purposes and business models. Various working groups compound DCMI, and between them the Education Working Group develops proposals for the use of Dublin Core metadata in the description of educational resources, posing particular emphasis on the development of strong, ongoing (formal and informal) working relationships among existing metadata standards initiatives. The kinds of information that this specification grasps are learning resources' basic characteristics such as *title*, *creator*, *subject*, *publisher*, *date*, *type*, *language*, and *rights*.
- The IEEE Learning Technology Standards Committee (LTSC) is chartered by the IEEE Computer Society Standards Activity Board to develop accredited technical standards, recommended practices, and guides for learning technology. A part of the LTSC is the WG12 Learning Object Metadata (LOM) [24] working group that develops Draft Standards for Learning Object Metadata. These standards specify the syntax and semantics of Learning Object Metadata, defined as the attributes required to adequately describe a Learning Object. The Learning Object Metadata standards focus on the minimal set of attributes needed to allow these Learning Objects to be managed, located, and evaluated. Relevant attributes of Learning Objects to be described include *type* of object, *author*, *owner*, *terms of distribution*, and *format*. Where applicable, Learning Object Metadata may also include pedagogical attributes such as; *teaching* or *interaction style*, *grade level*, *mastery level*, and *prerequisites*.

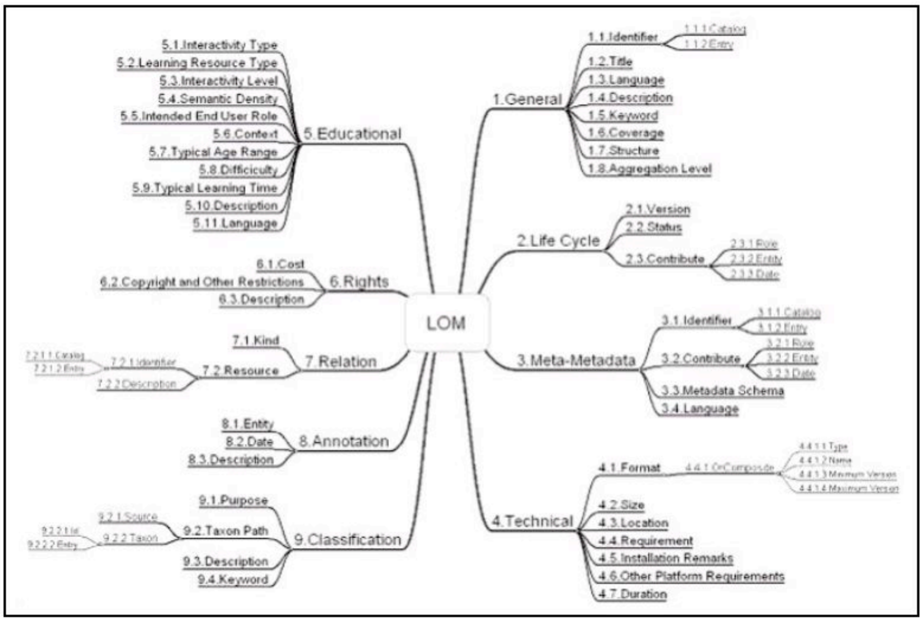

Figure 4 – The LOM metadata (from http://www.imsglobal.org)

- The ARIADNE Foundation [25] is a European project that develops tools and methodologies for producing, managing and reusing computer-based pedagogical elements and telematics supported training curricula. Its

Educational Metadata Recommendation is an application profile and implementation of the LOM specification that takes into account the specific needs and requirements of a community, highly representative of European Higher Education and Continuing Professional Training.
- Similarly, EdNA (Education Network Australia) [26] is an Australian national framework for supporting the use and re-use of educational resources on the Internet. It is organised around Australian curriculum and offers the DCMI-based EdNA Metadata Standard to support interoperability across all sectors of education and training in Australia.
- The CID group (Center for user-oriented IT Design) of the Royal Institute of Technology, Stockholm, Sweden, has developed RDF binding of LOM metadata [27]. This specification provides a representation of IEEE LOM in RDF (a Semantic Web language, described in section 5), in order to facilitate introduction of educational metadata into the Semantic Web. It is specified as a table defining the RDF property to use for each element in the draft LOM standard. This is very important for future web-based intelligent educational applications, since such a binding enables the RDF-based exchange of LOM instances between applications that implement the LOM data model.
- IMS Global Learning Consortium [28] develops and promotes the adoption of open technical specifications for interoperable learning technology, focusing on different issues in online learning, such as learning design, curriculum sequencing, content packaging, learner information, and question and test interoperability. Their specification is based on IEEE LOM.
- The Advanced Distributed Learning (ADL) Initiative [29], sponsored by the American Office of the Secretary of Defence (OSD), aims at establishing the interoperability of learning tools and course content on a global scale, anywhere and anytime. ADL best known product is SCORM (Sharable Content Object Reference Model), a collection of specifications adapted from multiple sources (such as IMS, IEEE, and ARIADNE) to provide interoperability, accessibility and reusability of web-based learning content, and is meant for content developers, learning designers and learning management system (LMS) vendors.
- Edutella [30] is a metadata-based peer to peer system for handling educational resources . The aim was to build a network for the exchange of learning objects between German universities (including Hannover, Braunschweig and Karlsruhe), Swedish universities (including Stockholm and Uppsala), Stanford University and others. The project is a multi-staged effort to scope, specify, architect and implement an RDF-based metadata infrastructure for P2P-networks based on the JXTA framework [31]. JXTA is an open source technology originally developed by Sun Microsystems, that defines a set of protocols and a platform to support peer-to-peer application development. The final aim is possibly to provide the metadata services needed to enable interoperability between heterogeneous JXTA applications.
- More recently, the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), which constitute together the specialized agency for worldwide standardization, have formed a joint technical committee, ISO/IEC JTC1 [32], in the field of information technology. A working group of this is focused on Information Technology for Learning, Education and Training and is publishing standard data models to describe collaborate learning activities, like *workplace* and *group*

information, *objectives of collaborative learning*, *expected outcome*, *name* and *role of participants*, etc. This initiative has been welcomed as a possible conclusive attempt to map learning resources' usages and semantics, however, the drafts published are not stable yet and there seems to be much more work to do.

These are jus the most important attempts to create metadata standards to facilitate communication and re-use, but this review is already enough in order to draw the following two conclusions:

a) It is quite difficult to have one only standard, and this is probably due to the nature of the Web and its extreme freedom: the 'battle of standards', eventually, will not necessarily come to an end since new organizations and requirements can emerge. Therefore specifications focused on interoperability (like SCORM) might result as the most useful ones;
b) Even if useful in exchanging learning objects and reasoning about their features, these kind of metadata are still semantically poor. The information they provide remains superficial, proper for a simple course construction or for the location of resources through key words, but not capable of linking them in a non-sequential manner. So, the features that carry the biggest pedagogical advantages and implications, such as advanced semantic browsing facilities between educational resources, are extremely circumscribed.

The intrinsic limitations of the representational strategies employed in LOs, we will see later in the following chapters, can be surmounted thanks to the usage of Semantic Web languages (in particular, ontologies). The detailed definition of the salient features of a domain in a SW representation, in fact, can be used to map different learning resources, and to allow a meta level of reasoning able to produce personalized and pedagogical *narrative structures*.
However, before describing these new technologies applied to learning material, we should perform an excursus in literary theory, and clarify what is meant by saying that a narrative has a *structure* that can be *formalized* and eventually *reproduced*.

4. Narrative Theory

Narratology is the name given to the critical and theoretical study of the numerous forms of narrative discourse, especially in literary and film studies.
If we want to briefly describe its theoretical origins, it is fair mentioning the influence of the work of the linguist De Saussure in contemporary narrative theory. In his book "Course in General Linguistic" [33], published posthumously in 1916, the distinction between "signifier" and "signified" is discussed, and a general theory of language that claims the primacy of the *form* over the *content,* is presented. Therefore, this means that the structure of the language, which can be abstracted from its everyday use, is actually the place where its essence lies. In other words, the semantic nature of a linguistic expression does not depend on its content, as apparently we are tempted to believe, but is tightened instead to the net of relations which constitutes the language phenomena as a whole. Another way to put this is that the parts obtain a meaning only within a wider system.

These ideas have been further developed by many scholars in different areas, and have become central in the French structuralism. This theoretical movement, in fact, through the 1960s and the 1970s has investigated the functioning of narratives, working on the assumption that, being linguistic phenomena, they could have been studied as Saussure studied language.
Actually, an earlier appearance of narratology is in Russian formalism. In particular, Vladimir Propp's *Morphology of the Folk Tale* [34] anticipated many of the methods of narratological analysis in its breakdown of a corpus of Russian folk tales into a finite number of constituent parts: thirty-one different morphological functions (mostly plot twists) and seven “spheres of action” (mostly characters).
In fact, the basic idea of narratology is to *scrutinize* the internal relations of a narrative's component parts, and *dissect* how these relations are constructed in practically any given aspect of the narrative text (such as plot, narration, sequence of events, and so on). The text's structuration can therefore be read as a system of meaning in its own right, which interacts with any apparent message the text contains.
The concern of a narratological approach is not with *what* a narrative represents, but with *how* it represents it.
This methodological orientation is fundamental in understanding the various interpretations scholars have proposed [35] after the first structuralist formulation of the abstract dimensions of a narrative. Generally speaking, referring to the work of Genette [36] and later of Chatman [37], we can in fact sketch out the structure of a narrative as the union of:

- <u>Story</u>: it is the “what” of what is told, namely, the conceptual space representing people, events and objects, the organization of different entities. Somehow, it also refers to the abstract chronological structure of events. It corresponds to the *signified*.
- <u>Discourse</u>: it is the “how” of what is told, that is, the specific way in which the basic elements of a story are re-organized and conveyed to the listener. In this way, different effects can be created, such as humour or surprise. This category includes and is influenced by another one, the particular *media* used to deliver the narrative. In fact, the choice of the media will always effect the kind of rhetorical stiles allowed, or, for example, other time-related constraints. It corresponds to the *signifier*.
- The <u>narration</u> itself: this dimension was firstly introduced by Genette, and refers to the unavoidable influence of the speaker on the final narrative’s effect. It is the “Qui parle?” problem: every narration is always in a context, and therefore assumes some peculiar meanings from it, at least the point of view of the speaker.

This theoretical model, firstly developed to describe “stories” in the classic acceptation (namely novels, romances, or any other work in literature), has been extended to be used with any kind of media that can be possibly employed in the delivering of a narrative (myth, theatre, film or even hypermedia [38]). In particular, considering the specific application domain of our system, we will try to implement a narrative structure within the philosophical realm, treating theories and principles as protagonists and characters, and problems and research areas as motifs and places. The general framework explicated by Chatman constitutes a useful high-level model to adopt, but, as we will see, the more a domain is studied in depth, the more a need for domain-specific narrative structures will emerge.

The work of Schank [39] is crucial to our research, since it emphasizes and structures the linkage between learning and narratives. His research, in fact, spans from narrative theory to philosophy of knowledge, and constitutes a fundamental theoretical background when trying to grasp the relationships between human's learning and storytelling abilities.
Basically he draws a line that connects intelligence, understanding, conversational structures and stories. In his opinion, since our knowledge scales down to the set of stories we are able to tell, the most interesting question becomes how we manage to get from one story to the other, namely how we constantly index new stories and relate them to the corpus of stories we stored in the past. Within this approach, intelligence is defined as a "massive indexing and retrieval scheme" that brings out the linguistic representation of some latent conceptual structure. He offers a wide catalogue of the kind of stories we tell and are told, based on their structure, their origin and their usage and therefore states quite firmly the boundaries of what should be considered an intelligent behaviour.
The equivalence he draws between the learning process and the narrative creation is one the underlying motifs of much research in the area; however, although being a detailed description of what goes on during understanding, this approach remains quite vague and does not try to give an account of the internal processes that correlate stories at the conceptual level, e.g., non linguistic. A better examination of the patterns that link the "gist" of different stories, in fact, would also bring benefits to the engineering of structures between learning resources.

4.1 Digital Narratives

The most interesting development of narrative theory, from this research point of view, is its translation into the digital world, namely, the existence of programs and languages to represent the dimensions linked to a narrative definition, support their dialectical interchange and, more generally, foster new ways to browse intelligently semantic spaces.
For example, in [40], tools based on narrative structures reach the aim of enabling communities celebrate and explore regional heritage. Communities, in fact, are accustomed to discuss in electronic forums, where basically the main activity is the mutual exchange of stories representing a standpoint on a particular subject. These stories, if properly indexed (as we will see below, through the use of ontologies) can be retrieved in novel manners, explored in a personalized way and compared using multiple viewpoints. In this way, the reader "does not just receive the narrative but actively constructs a story for themselves during the reading process".
Clearly, this approach brings some implications on the learning side: learning is constructed, it happens during a collaborative activity and is a process of *meaning-negotiation* with the context. The heritage collection treated in article, therefore, is encountered as a whole constituted of a net of meanings, and the navigation through the resources' description is at the same time autonomous (the user has control on it) and guided (by the semantic relations between the concepts-descriptors).

A more detailed explanation of the processes involved in the creation of a digital narrative is the one presented by Brooks [41]. The aim of his research, as stated, is to

employ the computer to "generate multiple narratives quickly and semi-autonomously" out of a pre-inserted "story" material.
This vision, in particular, applies to cinematic story construction, through the use of computer based storytelling system. A storytelling system is not "a magic box which creatively makes up a story when asked, but a system of specially stored and organized narrative elements which the computer retrieves and assembles according to some expressed form of narration". In other words, such a system has knowledge in order to create a discourse out of some specified content, and in doing so, it helps the author through providing an environment for non-linear, multiple point-of-view stories.
If normally the writing process produces a story that is then delivered to the audience, generating some feedback on the author, with the advent of the computer this process has changed. Computers, in fact, can provide some decisive support to the creation of stories, and not only as a word-processing tool.

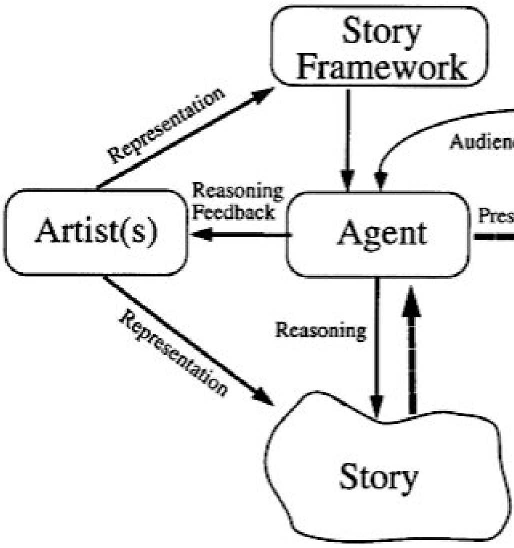

Figure 5 – The role of an agent in the story creation process (Brooks,1996)

As we can see from figure 5, the whole process is now focused around the notion of an *autonomous agent*. This is a software program that embodies the representation of a set of "low level" competencies, which are each "experts" at solving one small part of the larger problem domain. The idea of an agent has its origin in *Behavior-Based AI* (BBAI), as opposed to *Knowledge-Based AI* (KBAI), where the knowledge of a domain is formalized in a big system and is employed in an a-priori manner, usually without taking care of the possibility that the domain could have been changed.
A BBAI agent, instead, should behave differently depending on the changing layout of the environment, thanks, as we have said, of a series of low-level representations encoded in its "intelligence", which makes it an *adaptive* entity.
In the story construction scenario, an agent would have to operate within an environment of stories (more precisely, of their representations) and navigate them, namely, choose a sequence of story pieces based on its *hardwired* particular set of behaviours. In this way it becomes an 'agent on information' between the artist, the story and the audience.
Having stated this, the author can define a computational narrative as "a narrative whose story representation, structure and presentation are so intertwined with the functioning of a computational tool that the nature of the narrative reflects the nature

of the tool". Structure, representation and presentation are in fact the three main moments of the story production process, as realized in *Agent Stories*, the system Brooks proposes to instantiate his ideas. They correspond to the three specific environments used by an author to create a simple framework for a story creation. Let's see briefly their specific function:

1. The Structural Environment is where the structure of the narrative is described in abstract terms. This description, of course, relies on the theoretical models we have introduced above, and for example considers elements such as *speaker introduction, character introduction, conflict, resolution, diversion, ending*. The order of the elements is already itself conveying a specific meaning, namely, a genre. It is up to the author deciding how to organize them depending on what kind of effect he/she wants to create.
2. The Representational Environment captures the knowledge of the various story elements in the form of relationships between story events. So, for example, a series of links are defined: *follows, precedes, must include, supports, opposes, conflict/resolution*, and by relating the various story items a web of relations is created. The final goal of this environment is to express a useful and efficient way of intelligently reasoning about the elements in a story domain.
3. The Presentational Environment, finally, is where software agents work as text/video editors, intelligently sequencing and orchestrating the different story elements according to an agent's individual stylistic preferences. This is where all the *reasoning* takes place, the reasoning that lets the agents navigate the story web in a peculiar way. For example, the main point-of-view of an agent could be a character with a lot of oppositional links among its story elements, or the one with the greatest number of over all links to other story events. The final presentation of the narrative is usually built in time, that is, as a sequence of story events, but it could also be built in space. In this case the computer screen can be treated as a "multi dimensional stage on which main characters live and struggle through their narrative events".

It is worth to note, as we will see later, that these three steps may correspond to different ontological representations, and that there is quite a lot of research that has built on these seminal ideas using more recent AI and Semantic Web technologies. For that regards our final aim, the realization of a system for the teaching of philosophy through digital narratives, we will as well make use of the model just presented. Of course, we will have to translate it to our domain: the structure to be grasped, is the most common *form* of a philosophical system, or the set of *forms* a philosophical work might exhibit; the representation of the basic elements will rest on the relationships between theories, philosophical standpoints and research areas; finally, the presentation and navigation of the environment should be focused on the learning perspective, that is, on how to introduce concepts and "stories" in a way that facilitates the work of a student, or, more generally, of whoever wants to apprehend something new.

In conclusion, we agree with the author on two key points that he highlights:

- *Representation and reasoning are inextricably and usefully intertwined*: this means that at the core of a representation stands a conception of what constitutes intelligent reasoning; depending on the way we conceptualize a domain, we can present narratives which have more or less added value and interesting features.

- *Granularity is a central problem in digital narratives*: granularity refers to the chosen unit size for building story, and it embodies a trade-off between power and efficiency. If the story "bricks" are smaller, there are more ways in which they can be composed together, but the representation and reasoning tasks may become incredibly complex and subtle; conversely, if they are larger, it is easier to put them together but there are less ways to construct meaningful stories out of them.

This general framework and methodology to digitally represent a narrative has been instantiated in different areas. Between them, it is worth noting the game studies [42]. In such a scenario, the interface between the user and the application is often centred on a digital character that acts in a virtual environment and triggers different story-paths, consistently with abstract story-structures encoded in the system.
A number of analogous applications exist in the digital media field of study: for example [43] describes a children educational platform that, relying on the organization and description of contents adapted from an animated children's television series, aims at the reuse of the resources and at the involvement of the spectator on the development of a plot. In this case, the friendly user-interface is a domino-like board with tiles representing the different clips available. Children create sequences of tiles respecting some predefined rules (dependent on the narrative-compliant structure of the content), and subsequently can see a personalized animation in which they recognize a product of their sequencing of events and characters' actions.
Also here, the authors stress the fact that representation and reasoning are strictly connected, by saying that "to ascertain how we could reuse the content from the television show in the most effective manner, we analysed the 65 episodes of Tiny Planets [the name of the show]". The analysis of the resources available is crucial and determines the kind of granularity attainable and the possible plot intersections from the represented narrative units.

In the area of digital narratives, it is finally important to consider the results of the work of Scharfe [44, 45] who has presented a "narrative matrix" where three core dimensions in narratology intersect with their correspondent dimensions in semiotics, generating a powerful model that can be employed to analyse stories in general. According to him,

> "(…) narrativity can be defined as what takes place in texts where a complex relation consisting of three parts governs the relation between the text and that for which the text stands (…)".

The parts he is talking about are the instantiation of three general principles he acknowledges. These principles determine what a narrative is and what is not, and are thus defined:

1) Succession: in narration events and objects are not simply stated, as in an "objective" description, but are organized into a *sequence*. This succession is rooted in our experience of time and change. However, even if at first sight it may seem that the driving force that constructs a succession is some form of "invariable causality" (A must follow B), or of "counterfactual argument" (if A had not happened, B would not

have happened), this conclusion is not true. In fact, argues the author, it is essential that at almost any point in the narrative it is possible to envision alternative courses of action (the aristotelian *peripeteia*). Therefore, what keeps a succession together is not the strict law of causality, but instead a principle of transformation. That is, succession is a prerequisite for describing *change*, and without change there can be no narration.

2) Transformation: sequences in narration are not isolated, like episodical accounts, but are arranged in *patterns* signifying that some state of mind or some state of affairs undergoes some sort of change. These patterns, ultimately, correspond to out usual perception of meaningful unities, and let us define, for example, such things as *beginnings* or *endings* (which would not be defined by the only notion of time and succession).
3) Mediation: the last principle accounts for the meanings a narrative conveys beyond the simple content to which the expressions refer. Like in a fable, where there is a *moral*, any true narrative refers also to something that lies outside the world of text. Concepts like *premise*, *rationale* and *verisimilitude* explain this point, and show how it cannot be reduced to the principles of succession or transformation.
   Here lies the communicative power of a narrative, claims the author, and this is proven by the fact that we normally identify the understanding of a tale exactly in the grasping of this meta-meaning. The difference between an Aesop's fable and a recipe for apple-pie, for example, is all in this process.

These three narrative principles are therefore mapped to the widely accepted conception of semiotics, as defined by Morris [46]. Morris believed that semiosis consists of three parts: the relation between signs (*syntactics*), the relation between sign and that for which the sign stands (*semantics*), and the relation between the sign and the interpreter (*pragmatics*). Analogously, Scharfe, treating the minimal unit of a narrative as a *sign* in the semiotic sense, identifies the

a) Syntax of a narrative as the study of how these minimal units can be combined into meaningful sequences.
b) Semantic of a narrative as the study of the significance that minimal units obtain from the things that they represent.
c) Pragmatic of a narrative as the study of how collections of minimal units become the bearer of information distinct from the objects that the signs represent.

	Succession	*Transformation*	*Mediation*
Syntactics	X		
Semantics		X	
Pragmatics			X

Figure 6 – The matrix combining narrative dimensions and semiotics (from Scharfe, 2003)

The encounter of the narrative principles and the semiotic dimensions generates a matrix with nine spaces, and not just a plain mapping, explains Scharfe, because the

two way of explaining narrativity complement each other, and “each principle and each dimension can be seen as having three aspects, defined by each other”.
We reckon that this framework is very interesting, especially for that regards the definition of the third narrative principle, mediation. Moreover, we want to highlight the fact that Scharfe has formalized these and other ideas and insights about the narratives domain into an ontology [47], that is publicly available and will certainly constitute an important starting point in our research.

5. Argument Mapping

If we are interested in narratives for their being a fundamental way people learn, communicate and, in general, make sense of the world, we should equally consider argumentation as part of this process. In fact, it is possible to define argumentation as the social activity leading to the development of novel ideas, to the distinction of new concepts and, generally, new ways of seeing the world.
Following the definition of [48], reasoning and argumentation are closely related, but while reasoning is a “cognitive activity” in which “an actor constructs, analyses or evaluates inferences”, argumentation is “reasoning exercised in a social context”. Therefore, it follows that “to be good at reasoning involves the capacity of producing good inferences”, and that “to be good at reasoning is a necessary condition for being good at argumentation”.
Given these premises, it is clear how a formalization of the structure of a ‘good’ argumentation and its implementation in a computer language could be useful to our purposes. Building a sound narrative for learning, in fact, surely stands on the strength that links different ‘story units’ together, and this often relies on argumentative relations. So, the definition of sets of argumentative *chains* and of the way they relate items will provide a repository of *discourse schemas* we can use, in order to build useful narratives.

Just to give a little bit of a background, it is important to remember that the study of argumentation and rhetoric is ancient, and can be traced back to the Greek era (in particular, Plato, Aristotle and the Sophists). Nonetheless, for a long time, the main focus of this research has been forms of discourse that, eventually, were treated as more or less complex variations of the syllogistic patterns described meticulously by Aristotle in the *Organon*.
A quite important breakpoint, instead, has appeared during the modern study of argumentation, whose starting point is considered to be in 1957, with the work of Stephen Toulmin [49]. His work pointed out the fact that most real-life arguments do not resemble the formal argumentation schemes recognized by the traditional schools of thought; thus, Toulmin proposed a wider classification of the usages of argumentation, and a method to clearly map out the inferential and evidential relationships between the various claims involved in an argumentative structure.
This activity, called *argument mapping* (which actually have been used by scholars, more or less explicitly, since a long time), aims at facilitating the understanding of complex or obscure arguments written in prose or encoded in other media, and, for example, has been vital in fields like philosophy [50].

Going back to our days, the work of Robert Horn [51] is fundamental in this respect. In fact for more than 25 years he has been developing and testing an approach to the understanding of complex subject matters that lead him to the production of different books and *knowledge maps*. One of the most famous ones, titled “Can Computers Think?”, represents with words and images the great debate between scientists and philosophers on this topic. This type of maps, explains Horns, tackles the problems of *information overload* and *time constraints* that students (and generally, learners) have to face in the digital world. A map should visually give an overall sense of the debate, and highlight the different research directions involved, representing them in the form of positions supporting or contesting a given viewpoint. Doing so, the argumentation map should provide the user with the same functionalities a normal map would do, in a territory: guidance through unknown areas. Particular attention is to be paid to the language, specifies Horns, which “tightly integrates words and visual elements” and that, in his opinion, will be one of the future main vehicles of human meanings, thanks to it enriched and straightforward representative power [52].

Recently, work has also been done in order to support computationally the mapping of arguments. In particular, as said above, this kind of work is suited to support the philosophical work [50] [53], where complex arguments are usually presented in the form of long prose and the extraction of their logical structure is the basic for the grasping of the meaning. Eventually, the transferable skill these systems attempt to encourage is the *critical thinking* of the learner: the software is educational in so far as it provides tools to make the structure of a reasoning explicit to the user, and let him/her recognize a faulty argument from a sound one. Thus, visual techniques to build, view and evaluate an argument tree constitute the guidance and the “quality practice” a learner needs in order to become a real ‘critical thinker’.

A very interesting system, along this line, is ScholOnto [54, 55], for the detailed discourse ontology it employs and its original way to make sense of different resources without drawing on any specific domain knowledge. Following an approach called structural computing [56] (approach that claims the primacy of structure over data in computer science, in a vein that reminds De Saussure’s insights), in fact, this software provides an environment for scholars to make *claims* about *concepts* in documents.

In other words, this approach supports the scholarly activity of *interpreting* a document, and since the representation used focuses on the claims and not on the concepts, it allows the existence of different perspectives on the same raw materials. The formal representation employed is in fact a discourse ontology, that becomes itself the medium for humans to communicate, namely, as the authors say, “an ontology for principled disagreement”. If many approaches attempt to model a domain and use this representation to better describe and relate documents, with all the limitations due to the fact that domain knowledge is highly unstable and subject to evolution and change, the ScholOnto approach tries to go around this bottleneck. In fact, meaning is constructed by the same resources’ authors, who, before the publication of a paper, for visibility (or other reasons), clarify the relationship their work has towards the other existing research. Since every new contribution appears within a wider scenario, it owes ideas to other work and it exists opposing other contrasting positions. Thus, a paper can *support, oppose, be evidence for,* etc. (see figure below) some other work already published and linked to the ScholOnto server.

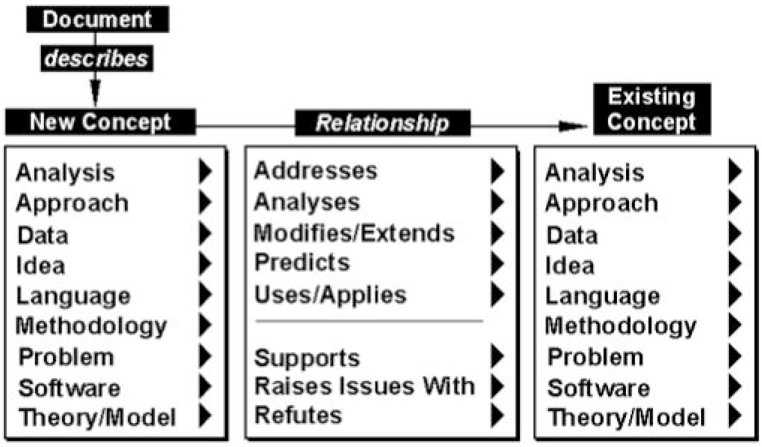

Figure 7 – The concepts and relations in ScholOnto (from B.Shum 2000)

The result of this process, in a pure *structuralist* vein, claim the authors, is a net of meanings composed semi-automatically, based on the relations of the items in a system, meanings which can be further exploited by a computational agent in order to help users make sense of always growing resources' repositories. In this sense, a new concept can be *contextualized* even if the domain or the theory it subscribes to are not formalized at all.

The payoff of this structured discourse is described as a series of services users can call to support the interpretation of a new contribution, or the examination of an old one, such as (taken from B.Shum, 2000):

- The *intellectual lineage* of ideas: e.g. where has this come from, and has it already been done? ("Are there any arguments against the framework on which this paper builds?")
- The *impact* of ideas: e.g. what reaction was there to this, and has anyone built on it? ("Has anyone generalised method M to another domain?" "Has anyone extended Language L?")
- *Perspectives*: are there distinctive schools of thought on this issue? ("Has anyone proposed a similar solution to Problem P but from a different theoretical perspective?")
- *Inconsistencies*: e.g. is an approach consistent with its espoused theoretical foundations? Is there contradictory evidence to a claim? ("Are there groups building on Theory T, but who contradict each other?")
- *Convergences*: are different streams of research mutually reinforcing in interesting ways? ("Who else uses Data X in their arguments?")

In general, these services are of two kinds, in relation of their being result of a pure graph analysis of the constructed 'web of meanings' (for example, a cluster analysis will identify dense networks of concepts and suggest a coherent topic), or their being result of a more focused semantic analysis of the relational types (for example, the lineage of an idea follows the connection of items along the *builds on* relation).

ScholOnto provides a complete set of tools to support the phases of the scholarly work, from the annotation of documents, creation of knowledge maps, visualization of them, browsing or retrieval of specific items through the services above.

This system is without any doubt an important comparison in our research. The argumentative relations it describes, and the use of them it carries out in order to provide semantic navigation between resources, are features that we will try to reproduce in our system. Our focus, however, will be consistently different, since the domain chosen (philosophy) and the perspective adopted (learning) will necessarily give a different shape to the kind of services a user would obtain.

6. Semantic Web

Having introduced already the names of some Semantic Web technologies (like RDF and ontologies) it is now the moment to examine in a more detailed way this emerging framework of research, and also give a couple of examples of existing systems that effectively implement it.

The Semantic Web (SW) is described by Berners-Lee [57-59] as an "extension of the current web, in which information is given well-defined meaning, better enabling computers and people to work in cooperation". Basically it is an attempt to provide more structure to the existing web pages, so that software agents roaming from page to page can carry out sophisticated tasks.
The distributed nature of the Internet, of course, is one of the central features of the Semantic Web, and actually, at the same time, its biggest problem. Treating the SW as an enormous decentralized database, in fact, posits the problem of the potentially infinite ways people could adopt in order to describe the meaning of their published data, leading to an unavoidable lack of understanding communication between programs and resources. Decentralization, therefore, requires compromises: the idea of total consistency between the Web's interconnections has to be left aside. Nevertheless, a SW has a lot of potentials since the need to organize semantically the data on the Web does exist, and the vision of letting the machines operate with them intelligently, relieving humans from a constantly growing burden of work, can be realized.

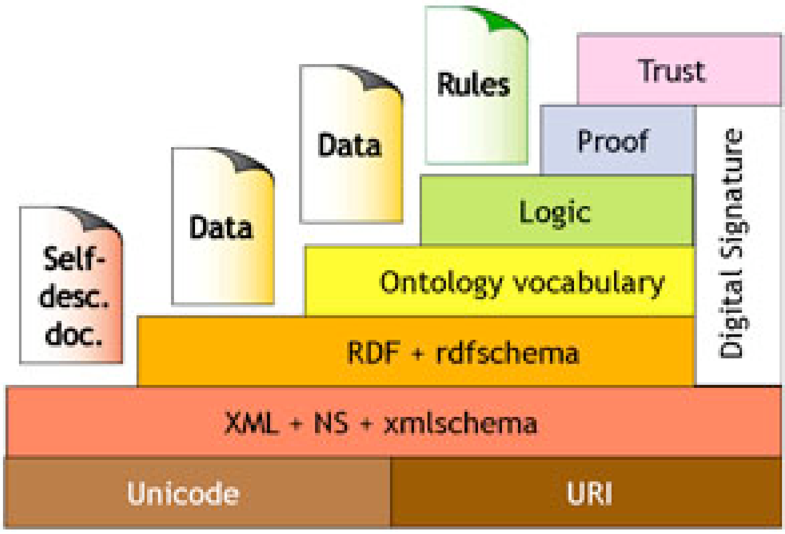

Figure 8 – The semantic web layers (after Berners-Lee 1999)

In order to do so, data must be structured and related to sets of inference rules. Computers could therefore conduct some automated reasoning on this huge *knowledge base*, as far as it is formalized following some consistent and well-known techniques. *Knowledge representation*, a discipline coming from the field of Artificial Intelligence, investigates this issue since twenty years ago, thus, more recently, it has had a central role in the development of the Semantic Web framework.

This framework, as shown in figure 8, consists of a series of continuous layers that stand one on top of the other, taking advantage of the representational power of the closest technology underneath and giving more human-like abstraction capability to the closest technology above. So, for example, while the XML layer represents the structure of data, the RDF layer represents the meaning of data; the Ontology layer, instead, represents the formal common agreement about meaning of data; above all these stands the Logic layer, which enables intelligent reasoning over meaningful data. At the extremities of the figure, instead, we find on one side the fundamental specification of the Web architecture, the Universal Resource Identifier (URI), a string of characters that uniquely defines every resource (situated on the Web, or even in the real world); on the other side a proof language, a sort of RDF that would allow agents retrieve knowledge securely from different sources, and use it for the most delicate operations.

Of these technologies, especially two of them are already widely used and are constantly augmenting the *semantic mark-up* of the old Web pages: the eXtensible Markup Language (XML) and the Resource Description Framework (RDF) [60].
XML lets users define their own tags, and use them within normal Web pages in order to provide arbitrary structure to a document: in this way the content of a resource should appear clearly and, if the semantics of the tags is known, a software parser could analyze the page and get specific results (that eventually will always point at some URIs). RDF, instead, aims at expressing the meaning of the resources, describing them through a subject-verb-object codification style. The triples thus obtained could be written using XML tags, and their semantics essentially says that a particular thing 'X' has a property 'Y' with a value 'Z'. In this way, the triples create "webs of information about related things", and connect resources in a more human-like manner.

Even if the RDF layer already offers quite a strong representational power, it is not enough in order to overcome many ambiguity problems: for example, two different words (or identifiers) could be used in order to refer to the same concept. Consequently, there is the need of a meta-level that describes these common meanings, something like a document or a file structure defining mappings between different databases. Ontologies [61] [62] [63] provide this functionality, and are actually one of the hottest areas of the current Semantic Web research.
There are various debates around the definition of an ontology, nevertheless, since this is not our primary concern, we accept the definition of Gruber of an "explicit specification of a conceptualization". In other words it is a formalized theory of what exists in a particular domain. The simplest ontology is a taxonomy (namely, a tree-like data structure that defines classes of objects and relations between them), endowed with a set of inference rules, which allows advanced manipulation of the classes (for example, some cross reasoning between them). Ontologies, therefore, constitute the backbone of the Semantic Web, since their expressiveness transforms them into some sort of universe of discourse for data manipulation.

Within such a scenario, a number of different applications and systems that make use of the technologies presented above have been developed. It is not the purpose of this review going through all these attempts, so we will just recall some examples that aim at the evolution of the browsing, retrieval and classification of resources. In fact, if the classic *key-word search* performed through an engine like Google [64] finds us a list of resources, connected merely by a *string* similarity, a more evolved *semantic search* that considers the metadata associated with the resources would get a series of results from different repositories, linked by some ontological knowledge.
A system like this is the one described by Guha and colleagues' [65]: building on the important "distributed extensibility" characteristic of the SW, they propose an improvement to the traditional Information Retrieval (IR) technologies, based almost purely on the occurrence of words in documents. TAP is an infrastructure that provides simple mechanisms for sites to publish data onto the SW via a minimalist query interface called GetData. Pure HTML pages are scraped and knowledge is formalized into RDF files. This technique, plus the manual annotation of other resources, has provided a knowledge base where to test this *semantic search*, whose results are then formatted and presented to the user as augmented 'classic search' results.

Another example of a SW enhanced system is the Simple HTML Ontology Extensions (SHOE) language [66] , an application of SGML and XML that allows users to define extensible vocabularies (that means, ontologies) and associate machine understandable data to them. In this way, Web pages can be easily marked up and searched using the ontologies. These ones, in fact, being selected from a drop-down menu, effectively provide a *context* for the search, through the usage of their knowledge encoded in classes and relations.
Piggy Bank [67], instead, is a recent tool integrated into the usual Web browser that tries to augment the users' experience of the Web by giving them the possibility to extract individual information items from within Web pages and save them in SW format, that is, encode them in metadata. This approach aims at resolving one fundamental problem of the SW, the scarcity of annotated resources compared to the proliferation of applications that claim of generating an added value out of them. This is described by the authors as a chicken-egg problem, which could be solved with the integration of a SW tool into the usual web browser. Doing so, vendors and publishers on the web should see much clearly the value in offering RDF specifications of their data, and the SW would finally start developing on large scale.

Finally, it is worth remembering that the same project of the SW, although having sparkled initiatives worldwide and within different research communities, has also its own critiques [68]. In this famous paper, the authors define three different contexts within which the SW could develop (the giant knowledge base, the ultimate digital library, and the communication device scenarios), and for each of them they outline the state of the art of the technology, and the weak sides of it. The questions issued and still unanswered are about knowledge stability (how well are the domains understood, and how much are they subject to future change?), competing conceptual approaches (is there any other way to represent knowledge, and, radically, is knowledge representable at all, in its every subtle aspect?) and cost/benefit (how much is the time spent annotating resources actually paid back?). This just shows how the SW path is still at the beginning, and how it is likely that new specifications or technologies, within such a newborn infrastructure for communicating knowledge, could still find their way and have success. However, we do not want to take these critiques in a negative way, but look at them as clever indications of where the major endeavours are needed.

7. Educational Semantic Web

Although the utilization of SW technologies in the field of education is quite a new research area, different authors have tried to foresee the possible implications and propose their vision into a consistent scenario. We will firstly go though five of these generic frameworks' description, and then, in the following three sub-sections, we will examine three different types of existing applications which actually employ the above technology to support learning. In the order presented, these applications aim at

a) Enhancing the learning objects reusability by linking them to an ontological description of the domain, or, more generally, describe relevant dimension of the educational process in an ontology (section 7.1).
b) Providing a comprehensive authoring system to retrieve and organize Web material into a learning course (section 7.2).
c) Construct advanced strategies to present annotated resources to the user, in the form of browsing facilities, narrative generation and final rendering of a course (section 7.3).

A seminal work in the emerging Educational Semantic Web was done by Mizoguchi and Bordeau [69], who defined the new "Instructional Design" paradigm as the evolution of Intelligent Tutoring Systems and Interactive Learning Environments, that is, as a "process by which learning events can be defined or described, independently of their instructivist or constructivist orientation". This new paradigm is fostered by the introduction of ontological engineering in the educational field: in fact, from the analysis of the computational semantics of an ontology it is possible to map out the solutions this technology can bring to the most common problems of instruction.
An ontology can be described as a three levels device: in the first one it appears as a structured collection of terms, a taxonomy that elicits the concepts' hierarchy in a particular domain; in the second level it provides formal definitions of the concepts, relations, constraints and axioms, all of which make the ontology more operable for computer agents; at the third level, the ontology is executable in the sense that, as it happens in task ontologies, "models built based on the ontology run using modules provided by some of the abstract codes associated with concepts in the ontology".
If this view is translated into the educational scenario, the authors claim that the first feature supports the sharing of domain conceptualizations between humans, as a common vocabulary for representing the knowledge; the second feature enhances computer's intelligence, and therefore bridges gaps between humans and computers; the third one, instead, makes this knowledge operative and let computers decide actions to perform within a system thanks to activity-related concepts (i.e., task ontology).

Stojanovic and others [70] also agree about the fact that ontology are the most important improvement the SW brings to eLearning technologies. In an Educational Semantic Web the everyday activities would be ontology development, ontology-based annotation of learning materials, composition of resources in learning courses and active delivery of the learning materials through eLearning portals. The authors define three principal criterions for locating learning materials, namely, what the learning material is about (content), in which form the topic is presented (context) and how it is presented in relation to other materials in a learning course (structure).

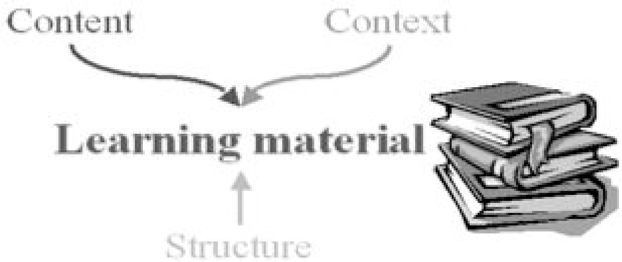

Figure 9 – The learning dimensions (Stojanovic, 2001)

Following this classification, they provide some examples of the kind of ontologies that could support the description of a learning resource. Domain ontologies, for that regards the content, would solve problems due to language ambiguities, and would evolve basic keyword queries into semantic searches. A context ontology, instead, would identify learning contexts such as an *introduction*, an *analysis* of a topic, or a *discussion*, or *presentation* contexts such as an *example* or a *figure*. Finally, structure ontologies would serve to specify the construction-grammar to assemble small bits of information into personalized and quick-delivered learning narratives; concepts like *Prev*, *Next*, *References*, *IsBasedOn* etc. constitute the semantic connections to build a "Lego" learning system tailored to meet individual skill gaps.
The three dimensions obviously would also be the main pathways to access a learning repository: resources can be accessed through a semantic query on one or more of them, or through a conceptual navigation based on the ontological representations available. This breakdown of the learning dimensions in a SW environment is quite useful, in fact we will use it later to identify the scenario of our own research. In particular, we will try to map it to the theoretical dimensions of a narrative, and compose the two approaches into one single view that integrates the learning aspect with the narrative one.

Another overview of the future implications of ontology usage in teaching and learning is proposed by Wilson [71], who gives a clear and useful summarization of the potential benefits of it in the following points:

- Students are provided with advanced browsing and searching support in their quest for relevant material on the Web.
- Syntactically different but semantically similar resources can more easily be located.
- The same work involved in creating an ontology can directly benefit learners by helping them to visualize and comprehend the relationships between concepts in their domain.
- Information can be shared across educational applications, enabling reuse not only of learning objects but also of domain knowledge and pedagogical strategies.
- Learners can be provided with the intelligent and personalized support that they would otherwise miss out (for example, personalized courses can be generated on demand).

In a similar way, the author outlines also the implicit risks of a serious employment of the technology in the educational areas:

- The ontology development process can be difficult and costly: the more expressive the ontology, the more complex and time-consuming this task; moreover, achieving an 'objective' representation of a domain is next to impossible.
- The context within which an ontology is supposed to be used tacitly constraint the definition of its concepts; so, for knowledge to be effectively shared, this contextual information must be formalized as well.
- Rich and complicated ontologies, far from the hierarchical structure of taxonomies, carry great expressive power, but are hard to comprehend especially for end-users.
- Since communities from different backgrounds (like library science, knowledge engineering, business) are involved in the ontology development process, there is a lot of overlap and reinvention, or many cases where the same things are defined differently.

A precise discussion of the relationship between SW and eLearning is also offered by Devedzic [72], who stresses the possibility of an improvement in AIED (Artificial Intelligence in Education), but only if the new technologies are firstly properly understood and digested. Various characteristics of the traditional ITSs, in fact, (as we have seen with ELM-ART, section 2) are already grasping key aspects of the learning experience. Thus the problem is to determine exactly where the ontological framework fits the most, and how to use it (annotation of resources, or just representation of usable knowledge).

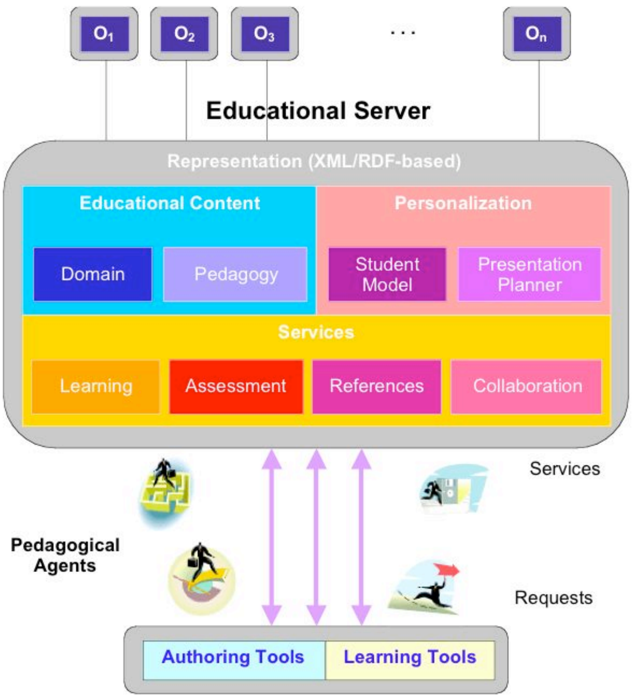

Figure 10 – Schema of a Semantic Web Educational Server (Devedzic, 2004)

The model he presents is very useful for it takes into consideration different SW technologies and all the possible protagonists and scenarios involved in any learning activity. We can briefly summarizes its main features:

- Ontologies are the backbone of the system, are used to codify different levels of shared understanding, like the vocabulary, the semantic interconnections, rules of inference, and to provide the structure used to semantically markup the resources available (this markup is then recorded in other formats, like XML, for better interoperability). The kind of ontologies needed to cover the whole learning experience should be about *domain* characteristics, *pedagogical* approaches, *student* models, and *presentation* styles.
- Services like search agents, information brokers, filters and integrators constitute the interface between the users and the knowledge base of the system. Moreover, they guarantee also interoperability between different applications on the Web at the semantic level, allowing the end user to be employed in complicated operations of *learning* (course offering, integration of educational material, tutoring, presentation), *assessment* (on-line tests, performance tracking, grading), *reference* (browsing, search, portals) and *collaboration* (group formation and matching, class monitoring).

Stutt and colleagues [73, 74] instead describe in a detailed way a scenario where one of the major problems of the SW, the competing and overlapping nature of its ontologies, would be overcome by the existence of a multiplicity of community-based Semantic Learning Webs (SLWs). In fact, since the nature of the medium is distributed, it makes sense to let agents construct ontologies and repositories in a distributed way. Communities would build so-called "knowledge charts", in order to represent the information of their interest, while specific "knowledge browsers" would navigate this digital spaces looking for consistency and correlation between concepts. The issue the authors address is essentially the need of *context* of the learning process. In fact, relying on various communities and not on a central and 'objective' repository, the technology offered by the SW could support one fundamental learner's necessity: the possibility of structuring and locating a single piece of knowledge within a local panorama (the *knowledge chart*), and possibly, be able to move on to even further related areas (other *neighbouring* knowledge charts). The interpretation of information is thereby fostered by the navigational capabilities of the SLWs.
Such a scenario is then instantiated using some existing technologies, and pointing out where more work has to be done. In particular, ontologies are used to represent domain knowledge (the content of the learning), argumentation schemas (the relations between pieces of knowledge) and pedagogical narratives, while other useful technologies deal with the visual representation of the knowledge charts, information extraction for automatic ontology population, annotation and semantic browsing of the resources.

7.1 Ontology enhanced eLearning

We can now examine some examples of real systems that make use of ontological engineering to overcome the common problems associated with learning objects' usage. As we have seen, these problems derive from the scarce semantic depth of their meta-descriptors, and lead to weak ways to re-organize them in a non-sequential manner. The augmentation of a LOs or any other resource's semantics is achieved along different dimensions. The ontologies related to this task, in fact, try to model not only the referring domain knowledge of the learning material, but, more generally, all the aspects possibly involved in the educational experience. We will see below which these aspects are, and what kinds of improvements are thus achieved.

The work of Koper and his team [75, 76], at the Open University of the Netherlands, is a fundamental milestone in the field of advanced eLearning technologies. One of the starting points of their research is the recognition that the success of an eLearning strategy does not rely on the medium (Internet) itself, but on the pedagogical design used in conjunction with the medium. Therefore it comes natural to formalize and clarify the dimensions of a pedagogical design, in order to instantiate them during every learning event.
A *unit of learning* is defined as the smallest meaningful 'chunk' of a learning event, that is, the smallest building block capable of carrying its own semantic and effectiveness towards the attainment of a learning objective. Learning objects, being extremely poor in their metadata definition, cannot fully exploit their most important feature, namely their being re-usable educational entities. In order to make their usage as flexible as learning management systems would like it to be, the authors have leveraged the difference between learning objects and units of learning by defining precisely the pedagogical dimensions of the latter, and use this meta-model to exchange and work with the formers. In other words, as they say, their basic idea is to:

a) Classify, or type, the learning objects in a semantic network, derived from a pedagogical meta-model,
b) Build a containing framework expressing the relationships between the typed learning objects and
c) Define the structure for the content and behaviour of the different types of learning objects.

An Educational Modelling Language (EML) [77] has been defined in order to describe the features of a unit of learning. These features basically represent the meta-model behind any pedagogical model, that is, an abstraction at the same time capable of expressing semantic relationships between pedagogical entities and of remaining pedagogical neutral. The meta-model is composed by four packages (figure 11):

1. The learning model, It describes how learners learn based on accepted consensus among learning theories. There are concepts like *external word*, *situation*, *cognitive state*, *stimulation*.
2. The unit of learning model. It describes how real instantiations of learning practices are created, given the learning model and the instruction model. Basically it contains the knowledge necessary for designing a learning event. It deals with issues like the *roles of staff* and *learners*, the *objectives* of a *group*, the *prerequisites* of the learners, *context* and *assessment* of learning etc.
3. The domain model. It gives information about the type of content and the organization of that content. In fact every content domain has its own structuring of knowledge, skills and competencies (e.g. math, or philosophy)
4. Theories of learning and instruction. It formalises the theories present in the literature, and collects them into four categories. The *empiricists*, adopt a purely behaviouristic approach. They assume that knowledge is based on experience and that processes can be observed, predicted and analyses independently of the context and of the internal state of the learner. The *rationalists*, focus on cognition as the medium between a person and the environment, and therefore treat it as the real force that generates knowledge.

The student is given a central role in the education process, since he is the builder of his own knowledge. The *pragmatic and cultural historic* approach, instead, considers knowledge as distributed between individuals, tools and communities, thus locates in the situation and the cultural-historical context the determining forces that drive the learning experience. At last, the *eclectic* model, combines different features from the other three positions.

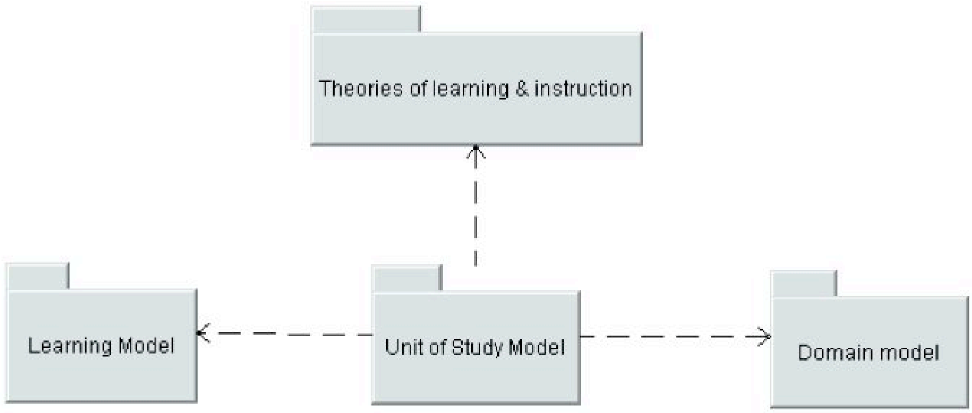

Figure 11 – The dimensions of the pedagogic meta-model (Koper, 2001)

The integrated meta-model should therefore overcome the LOs shortcomings by explicitly declaring the fundamental constraints of any educational activity. The model is further analysed by the authors along seven basic requirements (completeness, pedagogical expressiveness, personalization, compatibility, reusability, formalization, reproducibility) and judged capable of enhancing what can be done in online learning. Some of the expected outcomes are:

- Coordination of multiple users.
- Integration of learning objects and services.
- Providing a learning activity layer over learning objects and services.
- Supporting dynamic personalization/adaptation.
- Supporting multiple pedagogical approaches.

Gasevic and colleagues [78] propose a system that improves LOs usability through domain ontologies. In fact, usually, due to the dual structure of LOs (metadata plus content), there could be two usages of ontologies in regards to them: ontologies that describe LOs' metadata, and ontologies the describe LOs' content.
The first ones act on top of standard metadata schemas, like the ones we have introduced above (e.g. LOM), enriching their meaning and giving more context to their usage. The second ones instead are domain ontologies which authors can create and use in order to semantically mark-up directly the content of a learning resource. Later, the teacher can extract annotated parts of documents and re-assemble them into a presentation or a course.
This second solution is the one the authors point out as the key advantage of SW technologies on eLearning, supporting the maximum reusability and semantic "freedom" (since different referring ontologies allow different semantic mark-up on the same document). The figure below illustrates the system's workflow and the technologies involved.

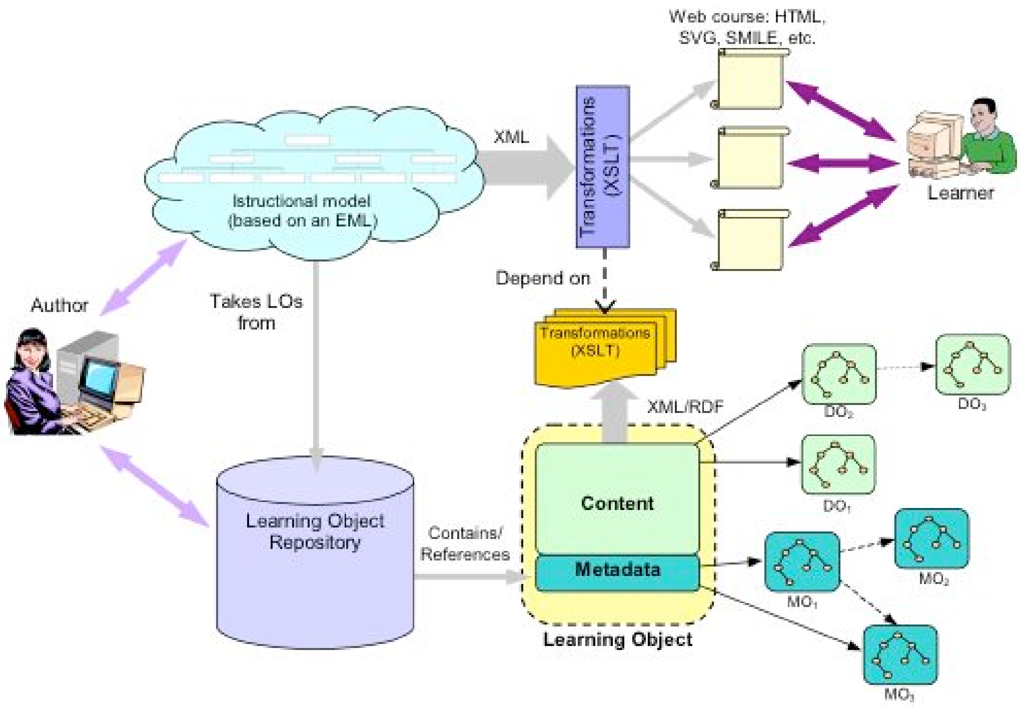

Figure 12 – eLearning process enhanced by ontologies (Gasevic, 2004)

It is worth noting the following characteristics of such architecture:

- LOs content can be produced in many different ways (text, slides, video, etc.), but its description should be encoded into some well-known metadata schema. LOs repositories are distributed sources of LOs and can contain either the metadata associated with them or the reference to the metadata on the Web. An author accesses LOs and integrates them into an instructional model of a course, designed according to an education modelling language (e.g. EML).
- Ontologies are used for both the description of metadata (MO) and the description of the content (DO). These ontologies do not necessarily have to be created by the authors, although some user-friendly tools can help them build their knowledge models, for example, during the annotation phase.
- The annotation process relies on the ontologies available, and is supported by specific tools capable of producing semantically marked up Web resources (that in this case are LOs) from different raw documents, like for example HTML pages, Scalable Vector Graphics (SVG), etc.
- The communication between the different technologies is guaranteed by the usage of XML and XSLT. The first one can be easily obtained from an EML instructional model, or from LOs' annotations, through common exporting features. The second one, eXtensible Stylesheet Language Transformation, automatically transforms the XML structured data into a learner-suitable presentation, formatted in basic HTML.

Elena [79] is an analogous application that addresses the limitations of metadata standards through the usage of ontologies and P2P technologies. Elena is defined as a *smart learning space*, that is, a <u>mediation infrastructure for Educational Services</u> (ESs). Since LOs do not provide enough vocabulary to model a real course they should be replaced by educational services, whose data model, instead, keeps into account the *pedagogical context* in which the service is offered (it describes things like *educators*, *resource type*, *technology type*, *physical places*, *terms* and *conditions*, *schedule*). A personal learning assistant (PLA) should therefore be able to query ESs in order to collect resources matching personal profiles and specific learning contexts, using some common technologies associated with Web-services (SOAP, WSDL, DAML-S). The broader framework of this scenario is a smart learning space, namely an infrastructure based on Edutella (a peer-to-peer technology to connect highly heterogeneous educational repositories, described above) within which ESs can operate and collect resources or information about resources. This learning management network is queried by the PLA, taking also advantage of the learner's profile in order to personalize query results. This system adopts ontological technology in order to overcome different problems:

a) To enable the various actors (educational services providers, that is, the peers in a P2P network) in the smart learning space to communicate with each other on a high level of abstraction.
b) To represent the natural language query within a semantic formalization: for example, the query "find a tutorial that explains the semantic Web to a novice" would make use, at least, of an ontology of learning resources ("tutorial"), an ontology of computer science ("semantic Web"), an ontology of learner's profiles ("novice") and an additional ontology that describes Web services' capabilities and query methods.
c) To annotate the learning resources.

The retrieval of the desired educational materials many times is not only a matching procedure between constraints and annotations, but exploits also other SW technologies (like RDF), locating resources with the help of reasoning engines.

Ullrich [80] proposes instead an "ontology that can act as a binding glue between different systems and services and serve as a basis for interoperability with respect to instructional matter". His ontology tries to capture the 'essence' of a learning resource, namely, its *function* abstracted from the particular domain it refers to.
This is partially accomplished by standard metadata, in fact possible resources can be identified as *Diagram*, *Figure*, or *Exercise*. However this representation is not structured at all since the values are provided as a simple list, and, as we know, with no semantics. For example, many times metadata mix instructional and technical information. Instead, the classes of the ontology that should capture the *instructional semantics* of a digital or text-book learning resource are organized, and empirically derived from the analysis of a number of sources (traditional text-books) and the mapping of their sections or sub-sections into functional instructional items.
So, for example, every *Instructional Object* (the root class, with a unique identifier and some basic metadata based on Dublin Core) can be a *Concept* (the main piece of information being taught in a course, that rarely appears pure and alone, but in the form of one of its specializations and connected to other concepts) or a *Satellite* (an object that is not part of the main building blocks of the domain, but still an element that provides additional information about the concept, motivate the learner and offers engaging and challenging learning opportunities).
Subclasses of *Concept* are *Fact*, *Definition*, *Law*, and *Process*. Subclasses of *Satellite* are instead *Interactivity* (a general description of any 'active' process involving the learning, like an *Exploration* or a *Real-World-Problem*), *Example* (something that can illustrate a concept), *Evidence* (the support of a claim, a proof or a demonstration), *Explanation* (that provides additional information about a concept). The author has

also set up an online forum to enhance the scope of the ontology and foster its discussion.
This work is quite different from the precedents, in as much as it just proposes an ontology to map resources and substitute (or work in conjunction with) the standard metadata descriptors. So, it is obviously only one component of the complex framework constituted by a learning management system. However, we decided to include it in this review because it instantiates an interesting approach we share as well: that one of capturing the 'instructional semantics' of a resource, and particularly, of a resource that could be an abstract theory or anything related to it. Clearly, also in the field of philosophy there are such objects as theories or theories' constituents; therefore, it is worth keeping in mind Ulrich's conceptualization while defining our domain's main classes and relations.

Ontological engineering has also been employed to strengthen CSCL systems. For example, in [81] the Activity theory is used as a theoretical framework to formalize the fundamental concepts in collaborative learning scenarios: things such as people with learning goals, group structures, tools available, roles and tasks have been formalized into a computational model rich enough to represent the interrelations between all these elements. The ontology obtained, developed in XML and Java, can be used to design and develop CSCL environments. Furthermore, students' activities can be analysed and compared to the task's description, generating some coaching processes that assist the student in the learning process.
A similar attempt is the one described in [82, 83], where a CSCL ontology is proposed for both providing a vocabulary for shared understanding and for designing patterns of interactions between the different entities involved. In particular, this approach does not subscribe to any specific learning theory, but aims at defining the basic concepts and theoretical models useful in the instructional design process, so that the user could build a tailored CSCL design based on the tasks and the goals he wants to fulfil.

7.2 Authoring Systems

A fairly more complex type of applications in the SWED are the systems that points at supporting an author of a learning course recollecting resources and organizing them in relation to a particular approach or point of view. In this case, ontologies are not used only to describe a pedagogical strategy or the structure of a domain, but they become the main instrument to avoid "re-inventing the wheel" every time and to tackle the exponential growth of courseware and learning materials. The systems we are presenting below, therefore, produce reusable courseware, emphasize on the structure and the modularization of the authoring process and keep into account existing standards in order to support interoperability.

The Courseware Watchdog [84, 85] is an ontology-based application built at the University of Karlsruhe, in order to tackle problems such as the increasing number of topics in education, or the decentralization of resources on the Web. The retrieval, interaction and management of resources is becoming increasingly difficult, so, say the authors, a new and more comprehensive approach which integrates the content, structure and evolution of the courseware material is needed. With their words, "true interoperability does not only need data integration, it also has to consider the integration of applications".

In order to reach this aim, the Courseware Watchdog, building upon the KAON framework [86] (an open source ontology management infrastructure, compounded of tools for ontology management and application), is deployed as a set of tools that assist the user in

a) Understanding and browsing ontologies,
b) Retrieving relevant material
c) Querying semantically annotated resources repositories,
d) Organizing the collected documents,
e) Updating the ontology.

The broad range of activities supported by the application strongly relies on the usage of a single semantic model (the KAON framework), and it is worth describing it more precisely.

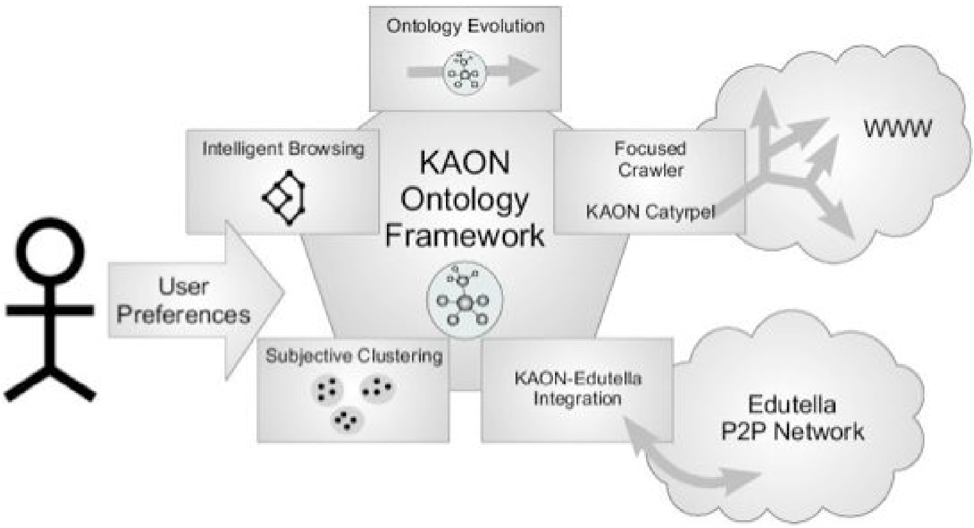

Figure 13 - The components of a Courseware Watchdog (Tane, 2003)

a) The user may or may not use an ontology he has created; therefore, it is vital for him to familiarize with the concepts and relations employed. Visualization techniques (display of hierarchies through concept lattices, in particular, using Formal Concept Analysis) and browsing techniques (relational browsing) are used in order to improve the interaction between the user and the content. Moreover, the visual interface is conceived in order to maintain always an open perspective on the ontology, as it were a map to browse: the left side of the screen shows it all the time, while the right side changes depending on which of the other tools is currently active.
b) A "focused" crawler[1] uses the ontology to direct its research, and lets the user define some preferences, like the weight to assign to different concepts or relations, or how large a radius around a selected entity is to be considered. This allows different levels of "sharpness" in the focusing, and the recording of the retrieved results (pages crawled, position of the relevant entities, link structures between pages) in a knowledge base.

[1] A web crawler is a program that collects data from the web automatically by following links extracted from web documents.

c) The Courseware Watchdog can also enter in the Edutella network as a full working peer, capable of querying for metadata on learning objects and of publishing local resources in the network. Since Edutella works mainly with RDF metadata, specific APIs have been developed to guarantee the communication with KAON ontology language and data model. The user is given an extensible set of basic query templates that can be filled in and employed straightaway, in order to facilitate inexperienced users to pose meaningful queries.
d) The data retrieved are stored as instances in the knowledge base of the relevant ontology, therefore, the user can practically organize them (for example, according to their topics) taking advantage of the same ontology. In order to improve the basic clustering techniques (which cluster only using document/term matrices and loose much of the implicit information contained in the language) some background (domain) knowledge is introduced in the process. Doing so, it is possible to provide "subjective" views onto document collections. For example, highlight differences and similarities on the content, or on its presentation form, or on the skills needed to approach it.
e) An ontology evolution component discovers changes and trends within the field of interest thanks to ontology learning methods. For example, it supports the introduction of new concepts and checks for inconsistencies, it recognizes "concept drifts" (that is, the change of meaning of concepts in constant flux, such as "Semantic Web"), it supports versioning ontologies (also if they change, it can still be useful to relate them), and, in general, it accompanies the user in the ontology lifecycle.

In conclusion, the Courseware Watchdog integrates a complex series of functionalities that represent quite well the whole authoring process a teacher is involved with, and support this activity in an environment always more web-based and ever-changing.

Also Aroyo and others [87, 88] have done various research in the same direction, attempting to fulfil the constant requirements for educational content flexibility and adaptability. They also reckon that through the usage of ontologies as the ideal infrastructure for integrating intelligent systems and enabling knowledge sharing, reusability and sharing can be achieved.
In this context, they propose an authoring task ontology (ATO) to support the authoring process in all its activities, to provide it with a methodology and with a vocabulary. The ATO is thus compounded of *authoring activities*, *sub-activities*, *goals* and *stages*, within a framework that formalizes the semantics of the whole authoring process.
This last can be divided in two parts: static and dynamic knowledge organization. The first one corresponds to the curriculum organization with instructional design models, while the second one refers to the tutoring strategy adopted in order to tailor the learning to the learner. As shown in the figure, the two layers are detached and constitute two different moments of the authoring process. At the bottom there is a reference to two instructional systems developed which instantiate these ideas, SmartTrainer (built at Osaka University, Japan) and AIMS (realized at University of Twente, The Netherlands).

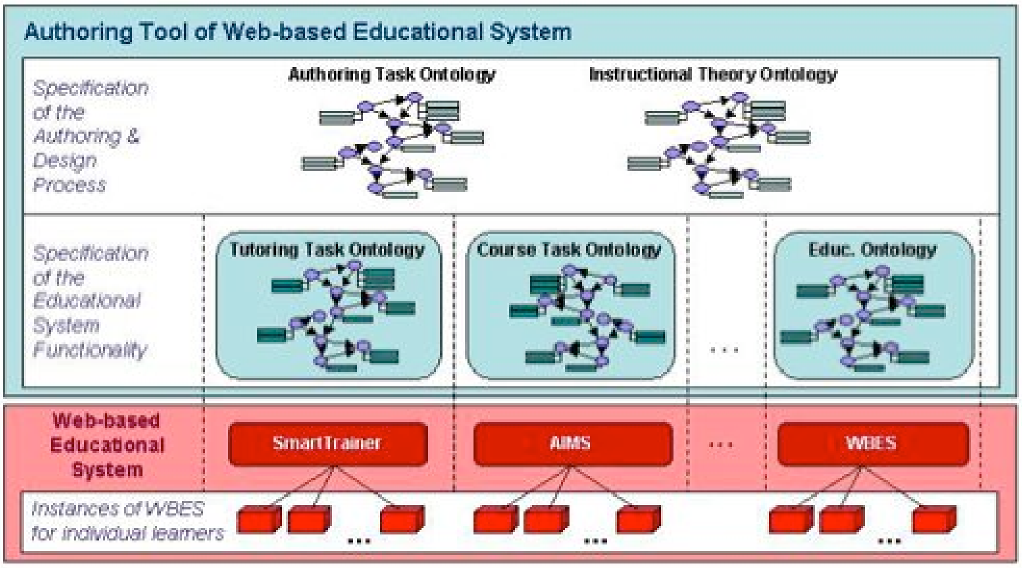

Figure 14 – Ontologies involved in the authoring process (Aroyo, 2003)

The task ontology, that is the main focus of the authors, aims at modularizing and specifying all the authoring activities at the maximum level, in such a way that the system's domain, the educational strategy and the educational goals could remain independent. The ontology describes the relations amongst the authoring tasks and the roles of the domain objects involved in the following terms:

- Sequence of activities with their activity type, constraints and input/output resources.
- Goal.
- Requirements.
- Constraints.

Analogously, the task ontology's entities are described by:

a) Nouns reflecting the roles of objects in the process (*concept, learning, activity, structure, resource, lesson, author, student, text, goal,* etc.).
b) Verbs representing the activities over the objects (*modify, edit, assign, return, update, select,* etc.).
c) Adjectives representing the modifications of the objects (*shared, unfinished, required, idle, updated,* etc.).
d) Other task-specific concepts (*concept prerequisite, lesson constraint, state, attribute, predicate,* etc.).

Moreover, these elements are put together to form primitive functions (simple objects within a specific domain, user or instructional model) or high level ones (collections of activities, functional groups of authoring tasks).

Finally, another similar system is the one developed by Kasai and colleagues [89] to <u>support the teaching of IT/information education</u> in Japanese high schools. This application both addresses teachers of IT education, and teachers who are training for IT education. In order to do so, it makes use of ontological representations of the domain knowledge (concepts of the goal of IT/information education) and of the structure of the instructional process (the purpose of the learner's activities and of the teacher's activities), obtaining an abstracted description of the resources that allows their reusability within different contexts.

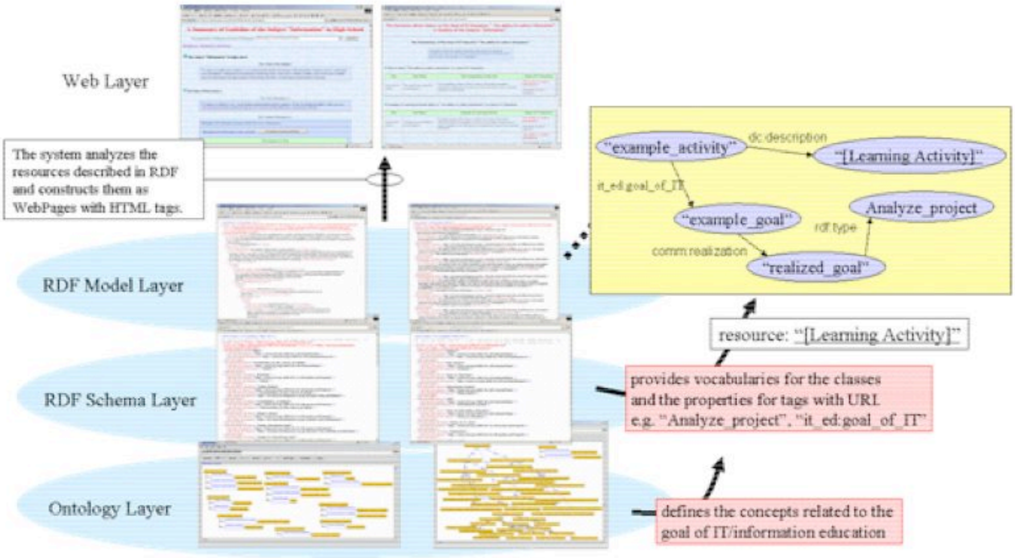

Fig. 15 – A four-layer model to generate multiple viewpoints (Kasai, 2004)

The system's architecture has four layers:

- The first one is the ontology layer, where all the concepts used are defined, together with the relationships among them. Also the relationships between different RDF Schemas (defined in the second layer) are explicated.
- The second one is the RDF Schema layer, where the vocabularies of classes and properties used in the third layer are defined.
- The third one is the RDF Model layer, where users can author metadata of various resources by using the vocabularies defined in the two lower layers.
- The last one is the Web layer, that is, the level of the user-interface in HTML.

This architecture allows the restructuring of knowledge into different viewpoints, depending on the perspective the user wants to take on the available material. It is interesting how it makes use of both RDF and ontologies in a cascading way, providing a high level of abstraction and independency between the modules.

7.3 Navigation and Presentation Systems

If resources can be adequately annotated and retrieved, the problem becomes how to browse them in an efficient and focused manner. As we have seen, digital narratives already address this problem, and basically associate the granularity of resources' description with their possible browsing possibilities.
However, also a number of systems in the hypermedia area have addressed the same issue, in order to achieve an increased independency between the navigational level and the resource level. From the browsing point of view, in fact, it interesting to see how we could locate the World Wide Web's limitations in the same core facilities it is provided with, namely, hypertext and Information Retrieval. The first one, for example, leads to an infinite number of paths users can choose, generating confusion and often also mismatching between the author's intentions and the reader's ones. The second one, instead, considered as a browsing facility mediated by search engines,

presents to the user a list of weighted documents having no other relation than the lexical one.
The reader, instead, should himself decide for the navigation strategy, independently of the fact that he already knows or not the content of the documents he is about to visit.

Conceptual navigation, supported by ontological engineering, has emerged as a solution to this problem [90]. Thanks to domain ontologies and argumentative ones, the links between resources and their narrative or pedagogical roles are computed from their description in a formal conceptual language, and may vary according to the situation. The navigation, therefore, happens at the conceptual level and can provide features such as *conceptual expansion* (some sort of lateral browsing, that takes into account concepts not directly related) *forward conceptual navigation* (a process similar to the free navigation in a hypertext, with the difference that is based on concepts) or *conceptual specification* (the retrieval of the direct sub-concepts of the initial one).
In all these cases, the navigation is called *ontology-supported*. Instead, when the paths the user can choose from are partially determined by the system, in a narrative or pedagogical ontology, the navigation becomes *ontology-driven.*
Systems of the first kind can be [91], where the annotated multimedia are browsed freely at the conceptual level or [92], where some learning goals called benchmarks (which describe in the form of a bundle of concepts what learners should know at key stages of their educational *iter*), are assembled by library developers to produce course material.
We are more interested, instead, on systems of the second kind, since they provide some narrative facilities and sometimes they also conjugate them in a pedagogical perspective. The following analysis tries to give more details of the research in this direction.

Story Fountain [93] is a tool developed to support a community in the exploration of digital resources, specifically stories. The background approach is constructivist, in as much as it lets the users engage with the subject matter, make their own interpretations and basically learn through a story sharing process. Users, in fact, ask questions about the domain (Bletchley Park, a second-world-war heritage site) and receive as answers some explicatory *paths* along the many annotated stories in the knowledge base.
Thanks to a domain ontology and a narrative ontology, the different stories annotated and stored in a database are later recollected in an intelligent way. Compared to a simple string matching retrieval, Story Fountain provides a great improvement towards the understanding of the stories; in fact, it generates semantic navigational paths as a result of the novel connection of different concepts. Moreover, since all the process is question-driven, it also supports the creation of learning paths in a flexible and autonomous way.
Of great interests are the six exploration facilities (corresponding to concept-pathways) that the system provides, and that are based on the narrative ontology:

1) Story Understanding, a view that highlights the conceptual structure of a story in terms of its central *characters*, events, *physical objects* and *themes* (these are classes of the story and narrative model).
2) Concept Understanding, a facility that collects all stories containing a selected concept, in order to do a comparative study between stories.

3) Concept Comparison selects stories related to multiple concepts in order do a comparison between concepts.
4) Concept Connection automatically draws pathways between stories thanks to the interrelations of concepts and events defined in the ontology.
5) Story Mapping gives a story perspective depending on a selected concept.
6) Event Mapping, finally, does the same thing but with the properties of events instead of stories.

At a higher level, the kind of interaction observed in the users while employing these facilities are classified by the authors into four exploration processes: accumulation (the aggregation of information of a particular type across different materials), association (identification of contingencies between different concepts or events), induction (usage of source materials to support hypothesis) and information gathering (basic exploration process without a detailed aim).
All these processes, of course, rely on the clear specification of the domain features and the narrative possibilities in the respective ontologies. Story Fountain is built as a Web application, making use of a Lisp server (where the ontologies are kept and queried) accessible through an Apache Web server, a MySQL database to hold the stories and Python to automatically generate the personalized input and output interfaces.

The Topia project [94], instead, is focused on the production of hypermedia presentations from the semantics of potentially unfamiliar domains (in their example, expressed in RDF). Although the authors recognize the necessity of human insight in order to generate a story, they still feel that there is a "subset of narrative and discourse concepts that one can automatically derive from semantics", and that includes, for example, the *order* of a presentation and the *grouping* of components into sections.

Figure 16 – The four phases in the Topia system (Rutledge, 2003)

This approach, therefore, being strongly domain-independent and computable, relies on the *clustering* of similar concepts and on their weight-assignment based on simple features, like cluster size. In fact, after the user prompts a query (phase 1 – semantic processing), the system tries to match it with the items in the RDF repository, and returns them together with the property assignment every item has (since RDF, as explained above, stores knowledge in the form identifier/property-type/property-value).
This set of collected items is then passed to the clustering algorithm (phase 2 – concept lattices), that has the function of looking for patterns in the graph (the RDF bundle of items) that act as landmarks for important locations. A *cluster* is a node with close proximity to a relatively large number of the originally selected nodes in the graph. A *concept lattice* is a particular clustering technique, and the authors use it in order to group the retrieved results into a partially ordered set of item-set/property-set pairs. Within this set, a *concept* is defined as the union of the items that share the same property, and it constitutes the basis for an informative structure around the items.

This totally "syntactic" process (since it does not make use of any explicit domain knowledge) generates groups of items that are weighted depending on their proximity to the cluster's centre, and are passed to the next module in order to generate a *structured progression* (phase 3 – clustering analysis). In addition, the system allows the user to specify the significance of certain concept's properties, thus modifying their weight in the final presentation. At this point, clusters have some measured rating of importance, which determines what type of discourse construct each cluster becomes and what order components are presented in. The components of structured progressions (the "subset of narrative and discourse concepts" we were talking about at the beginning) are the following, in order of importance:

a) Hierarchical Structure, similar to the division into sections and sub-sections in a textbook. Only clusters that are significant enough become part of the discourse hierarchy.
b) Meaningful Order, that is, the sorting of groups based on the minimum, maximum or average of their items' value for a sorting property (that can be entered by the user).
c) Recurring Themes, namely properties shared by multiple items distributed through the discourse hierarchy.
d) Tangents, the remaining least significant clusters that are not important enough to appear in the primary flow of the resulting presentation.

Finally, the structured progression has to be converted into a hypermedia presentation, since otherwise it would remain just an abstraction of how a presentation should be, without the details of its implementation (phase 4 – style sheet presentation). Therefore, guided by a principle of *discourse perceptualization* (that says that the user should perceive, at every point of the presentation, the overall structured progression and the context of the current point within it), four hypermedia communicative devices are introduced, which correspond to the patterns of discourse structure presented above:

a) Hierarchical Structure is conveyed following a "depth-first-traversal" principle (in a linear manner, all of a node's children are presented recursively before moving to the node's next sibling); a hierarchical navigation menu or an outline bar is provided; color is adopted to communicate certain aspects of a document.
b) Meaningful Order is translated into bookshelf and *manga* order (from the spatial point of view), into a temporal sequence or into *next* and *previous* button (from the timing and interactivity points of view).
c) Recurring Themes are highlighted when introduced for the first time, in the form of a full display of the topic; other times the reference is only indicated by canned text.
d) Tangents are transformed into informative pop-up windows.

The system has been developed and used in the context of the Rijksmuseum Amsterdam, to support visitors in the browsing process of the works of Van Gogh. For that regards the actual implementation, it is worth saying that the system does not make use of ontologies, but just RDF repositories (converted from the proprietary museum's database). From an initial HTML user interface, these repositories are queried using RQL, and the results are passed to JAVA programs that perform the clustering and output an XML structured progression. The progression is then re-transformed into a browser compatible format using XSLT style sheets.

Geurts and others [95], instead, describe a system that makes use of different ontologies in order to generate a complex presentation design. The background assumption of their work is that since also *information presentation design* is an inherently knowledge-driven process, it can partially be automatic and benefit from the exploitation of SW technologies. In their system the user does not only enter a query, but also specifies some characteristics of the final presentations, like the *genre* (biography or CV) and the *medium* (printed paper, hypermedia presentation). This is possible because the system takes advantage of various ontological representations: first of all of the domain, then of discourse and narrative, and finally of design and multimedia knowledge.

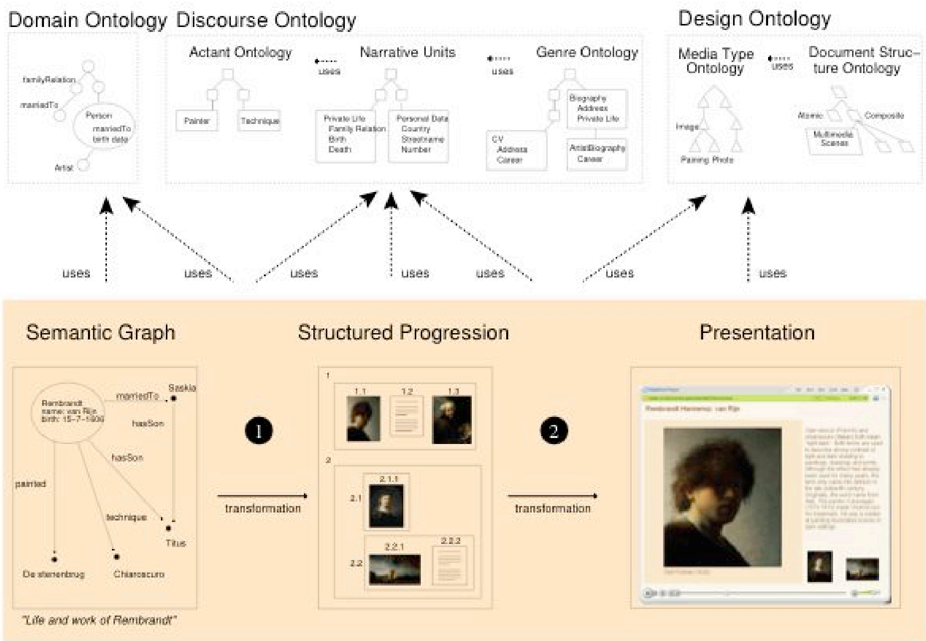

Figure 17 – The two-phase presentation process (Geurts, 2003)

So, if multimedia items are properly annotated, they can be matched by a user-query and retrieved in the form of a semantic graph (e.g. in RDF). At this point, *both* the domain ontology and the discourse and narrative one are used to deploy a structured progression (analogous to the one presented in the previous system's analysis). But in this case, it is worth noting, the clustering phase is not necessary anymore since the useful knowledge is already codified and available, thanks to the domain ontology. This allows the development of patterns within the retrieved RDF's bundles. For example, within a domain of painters and works, similar properties of the works can lead to novel connections between different authors, and so on. The domain ontology specifies the structure and the important relations in the domain, while the discourse one provides the rules to reason on the domain information and connect far-away resources into a coherent narrative.

In a second phase, instead, the structured progression is transformed into a final multimedia presentation. This is achieved in two steps: first of all a document structure is created, where all the decisions about the output medium are made explicit. Secondly, when all the detailed layout and formatting features are made clear, the document structure is transformed into a tree of formatting objects.

This approach does not use XSLT transformations or CSS style sheets to render the final presentation, in fact this languages can operate only on the XML layer of the

RDF syntax and XML is not taken into account by the authors, for its being poorly expressive from a semantic point of view. In doing so, they want to avoid any intermediate level of representation that would not let the knowledge be detached from the application level, and reusable in diverse contexts. Instead, through a Sesame server, the RDF stores are queried and interpreted thanks to the ontologies, without having to output any XML file. The transformation operations are guided by the ontological rules and implemented successfully both in Java and Prolog.

A slightly different system is Artequakt [96], developed at the University of Southampton, since it combines a powerful information extraction tool, to populate a knowledge base with information gathered on the Web, with a presentation module based on templates, to format the final output for the user. In this case, as we can see from the figure, there is only one ontology, the domain one, which is used to provide directions for the information extraction phase, and structure for the organization of the retrieved material.

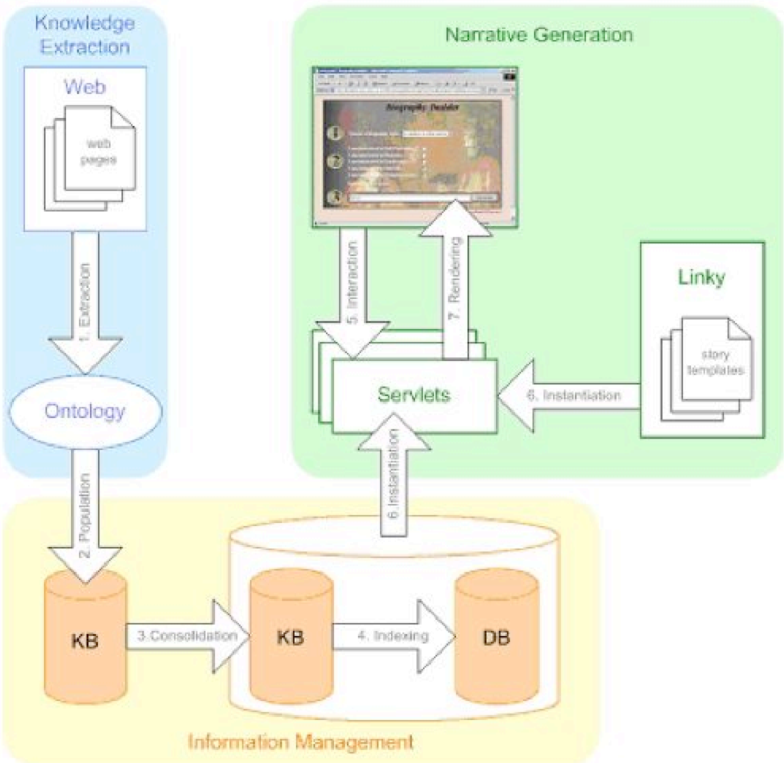

Figure 18 – Knowledge extraction and presentation in Artequakt (Alani, 2003)

Artequakt seeks for information about artists on the Web, stores it and re-assembles it to generate personalized narrative biographies. The presentation phase basically rests on human authored biography templates (authored in the Fundamental Open Hypermedia Model -FOHM- developed by the same university), where the basic structure used is a *Sequence*, that is, a list of queries to the knowledge base that have to be instantiated and inserted into the biography in order. In addition to this, templates may include their own text (like a sub-heading title), and some patterns to construct basic sentences if only the data are available.
Obviously, from the narrative point of view, the ontological organization of the information corresponds to the *story* level, while the *discourse* level corresponds to the fixed templates provided by the authors, thus not much reasoning or intelligence is

provided. It is worth, instead, analysing briefly the techniques used to automatically populate the knowledge base.
Due to the limitless vocabulary used in the documents on the Web, a background domain ontology (about artists and artists' lives) is coupled with a general-purpose lexical database (WordNet) and an entity-recognizer (GATE). In this way, the aim of identifying knowledge fragments consisting not only of entities, but also of relations between them, is reached. After a user's string-query, in fact, some documents are retrieved (also benefiting from some "trusted" sites collecting information about artists), and analysed first syntactically, then semantically. They are broken down into paragraphs and sentences, parsed grammatically so that relevant knowledge is extracted. At this point, the use of the ontology allows extracting binary relationships between these entities, and the querying of WordNet reduces the problem of linguistic variation between relations defined in the ontology and the extracted text (using three lexical chains, *synonyms*, *hypernyms* and *hyponyms*). The output of this process is an XML representation of the knowledge extracted and the breakdown of the documents, which is sent to the ontology server to be inserted in the knowledge base.

Another system that derives semantics from shallow annotations and then presents it in a personalized manner to the user, is the one introduced by Little and colleagues [97] . In this case, the annotated data are retrieved from the Open Archive Initiative (OAI), a community that has defined an interoperability framework to facilitate the sharing of metadata, expressed in the Dublin Core format.
Since from a basic key-word search on the metadata of this library too many items are retrieved (and between them, often there is no relation at all), the strategy adopted is to let the user *direct* the search process. For example, the first skimming of a large number of items is performed when the user selects only the relevant results, and the search process is iterated. During this operation it is possible to *infer* semantic relationships between resources and step-by-step *focus* exactly on the items the user is looking for.
The semantic relationships are derived directly from the metadata schemas (for example, the system may take a *dc.contributor* value for a chosen resource and search for resources which have *dc.subject* equivalent to this value), consequently, they will suffer from two internal limitations of this schema. First of all, since they are very specific to the Dublin Core metadata associated to the set of acquired media objects, they are hard-wired into the system as a set of pre-defined rules (and cannot be encoded in an ontology); secondly, they rely on the poor expressiveness of DC metadata.
An ontology is used, instead, in order to provide knowledge relevant to the presentational phase: the task to complete is to map semantic relations to spatial/temporal relations. The most relevant constraint, here, is the fact that while the possible semantic relations in a domain are infinite, the number of possible spatial and temporal relationships is limited. Therefore, the ontology is derived from the reduced set of top-level MPEG-7 (Multimedia Description Schemes specification) semantic relationships. For example, "X describes Y" (semantic level) is mapped to "X annotates Y" (MPEG7 specs) and then to "spatialBelow (X, Y), spatialAlign (X, Y)" (temporal/spatial level).
Finally, the Cuypers Presentation Generator [98], a five layers technology (compounded by a semantic structure level, a communicative device level, a qualitative constraints level, a quantitative constraints level and a final-form

presentation level) to translate the semantics of a presentation to its final output, is employed to send the results to the user's Web browser or media player.

The five systems analysed in this last section constitute an arrival point for our review, since they are somehow the most advanced results of SW research applied to the generation of narratives. In particular, we have seen that these narratives are powerful ways to let users interact with a set of resources, and that the usage of semantic descriptors, more or less automatically, can support a variety of tasks the end user can be involved in. Between them, the one that most interests us is the learning experience. So, with this in mind, we will describe in the next section what we reckon is still missing or in its infancy in respect to semantic learning narratives.

8. Gap analysis

From the research presented above, we can observe that SW technologies, in particular ontologies, have been used in various ways in order to overcome different problems involved in the design of eLearning systems. To sum up, we have found a useful knowledge representation approach in regards of:

- Domain characteristics;
- User modelling;
- Multimedia description;
- Pedagogical strategies;
- Authoring activities;
- Narratives description (literary narratives);
- Argumentative patterns.

In particular, since as we stated at the beginning, our specific interest lies at the heart of the intersections of three different areas, Semantic Web, Learning and Narratives, it is fundamental noting how the ontological representation of an educational process and the one of a narrative may overlap.
At a more accurate analysis, in fact, if we consider the well-known modelization of Stojanovic (presented in section 7), as opposed to the most typical structuralist breakdown of a narrative (presented in section 4), it is possible to note how four out of the five dimensions involved actually have the same meaning (Figure 19). Thus, they can be represented by the same ontological knowledge. In order to understand this, we remind that content and story refers to *what* the learning material or the narrative is about, while structure and discourse refers to *how* the learning material or the narrative is presented.
The only dimension left out is the contextual one that, as we explained, hints at how resources can be annotated from a pedagogical perspective. It therefore appears clearly that this last dimension would correspond to the already discussed pedagogical knowledge, expressed by a final third ontology.

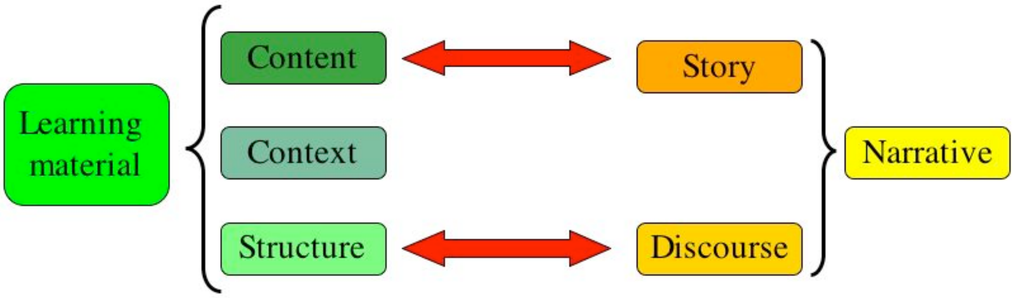

Figure 19 - The mapping between different breakdowns/dimensions.

It may seem, at this point, that we possess all the tools needed to construct a framework for digital narrative for learning. However, and this is actually the research gap we are pointing at, we believe there is still not enough specification and formalization of the narrative dimension, if not related to a literature perspective.

Most of the structuralist analyses of narratives, in fact, apply to novels, romances and in general to the domain of literature. As Schank says, instead, the domain of narratives is much wider and covers all what we can express and communicate. For example, scientific knowledge has its own way of delivering content and of structuring it. The high level dimensions of *story* and *discourse* may apply to a broad range of domains, but for that regards the low level specifications of them, there is still much work to complete.
A general formalization (through an ontology) of the narrative world as a whole still does not exist, and, more importantly, what does not exist is the formalization of a narrative approach to learning. In other words, there should be more analysis relevant to the following research questions:

1) Is there space for an ontology specific for learning narratives?
2) If yes, is this a sub-ontology of generic narratives, or does it stand on its own?
3) In which relationship does it stay in regard to other ontologies, for example the multimedia and presentation ones or the domain ones?
4) Is it possible to further define the features of a high level narrative ontology?

We believe that these research directions would provide a better understanding of the employment of computational narratives in eLearning, and therefore, we consider the subsequent research proposal as a possible instantiation of these problems in a specific and novel domain. This instantiation, eventually, will let transpire new answers and insights also to more general questions like the ones above.

PART TWO

FORMAL RESEARCH PROPOSAL

Title:

A navigational approach to the philosophical domain, through digital narratives for learning

1. Research Question Definition

The generic question that has driven the previous literature review and that will constitute the rationale of the future research is the following:

" How can we better support the learning process, making use of the new semantic web technologies?"

The question can be decomposed into its three main components: the first two are the learning process, defined exhaustively in section 2, and the Semantic Web technologies, described in sections 6 and 7.
Just to remind the reader of the results of the literature review, we interpret learning as a process that is *constructed*, *situated* and inherently connected to the human faculty of creating and understanding *narratives*. With Semantic Web technologies, instead, we refer to a series of languages and specifications created to describe and make better use of resources on the Web (or in the world), and in particular, between these languages, we highlighted the importance of *ontologies*.
The third concept composing the research question is that one of supporting a learning activity. The interpretation of this concept, however, is limited and dependent on the interpretation we have given to the other two components. These two, having now a clearer meaning to our eyes, allow therefore the reformulation of the research question in more specific way:

"How can we support the creation of learning narratives through distributed Web resources, making use of ontological engineering?"

The definition of the support we are talking about, lying at the crossway of narratives, ontologies and learning, is actually the answer we are looking for, and constitutes the proper result of this research.

2. Approach and Justification

The approach chosen to address this problem relies strongly on the usage of ontologies in order to represent narratives.
We interpret the concept of narrative, traditionally associated with the literature world, in a much wider sense. For us, in fact, a narrative can be compounded by any series of entities (textual, visual, audio), as far as it is possible to consider them all together as a unit conveying a specific meaning.
In particular, our aim is to investigate that particular subset of the narrative world, as just defined, constituting the specific narratives employed during a learning activity. We believe that through a formalization of these *learning narratives*, the educational process mediated by the Web can be fostered, and supported in terms of advanced resources' availability and reusability.

As we have seen (section 7 and 8 of the literature review), the other approaches focus on the ontological representation of different dimensions of the learning sphere

(domain, user, pedagogy, authoring, narrative). Then they try to arrange these representations together into a framework that makes them cooperate and achieve specific results within different scenarios.
In particular, in the educational scenario, we can identify as the most relevant knowledge the *pedagogical* one, which formalizes learning theories and educational strategies. However, in the systems described, even if this knowledge is used (at least in one case) in conjunction with the *narratological* one, the implicit links between the two are never made clear, or formalized.

Therefore, we reckon that a definition of the specific narrative structures employed in any learning process (in particular, the ones that are Web-based) is still missing. This definition will constitute out personal approach to the above problem of supporting learning activities through Semantic Web technologies.

3. Methodology

The methodology adopted to reach this objective is quite empirical, since it is based on the construction of a real eLearning system, for a specific domain, philosophy.
This task involves the definition of the *domain* knowledge, and the definition of a series of *learning narratives* strictly associated with the domain.

The task constitutes a valid methodology since we repute that the instantiation of the research question into a specific application will then allow us to investigate the possibility of an abstraction of the domain-related learning narratives towards a higher-level definition of them, applicable within different domains.

So, for example, if a learning narrative already pointed out in the philosophical field is the *critical explanation of a theory* (implemented as a conceptual *path* that highlights the supporting and opposing theories), this kind of narrative could become, at a meta-level, a learning approach modelled on the on the *analogy/contrast* dichotomy. These meta-level learning narratives will be the greatest contribution of our research, first of all because of their reusability within different contexts.
In other words, the implementation of such a system will let us investigate:

1) The relationship between some already existing narrative ontologies (the one of Scharfe [47], for example) and a learning-narrative one (is the second a subset of the first, or not?).
2) The possibility of a direct translation of learning theories into specific narrative paths.
3) The existence of a generic layer of this learning-narrative ontology, that defines paths for learning, abstracted from any particular domain.

4. Motivating Scenario

The scenario we have chosen refers to the usage and delivering of philosophical knowledge. The choice of the domain is motivated by a series of reasons that could be summarized in the following three:

- The lack of an explicit semantic formalization of philosophy, namely, of a consistent and detailed metadata definition;
- The large availability of digital philosophical resources (documents in a broad sense: text, image, video) on the web;
- The semantic richness of the domain, which could be translated into an advanced and non-trivial navigational capability.

Given these premises, we can now depict a real world scenario that would serve as an example of the functionalities we are looking for in a system producing learning narratives for philosophy.

Imagine Robert, a student doing research on the new frontiers of biology for his university course. While browsing the Internet looking for relevant material, he runs into an interesting article about a new discipline, sociobiology. Skimming through the text he realizes that he missed the overall point of the article, because there is a concept that still is unclear to him, “evolution”. What he needs is to locate the resources that would fill the gap that does not let him carry on his research. Unfortunately, a normal Google [64] search is too vague, and retrieves information that will just reduce his focus. Therefore, through a browser plug-in (analogous to Magpie [99]), he highlights the unknown concept and selects, between different ones, a specific narrative path related to it, let’s say, “concept explanation”. The system, making use of a domain ontology (in this case a philosophical one) locates the position of the concept “evolution” and of the various theories associated with it, within different research areas. The correlated resources are gathered and, through narrative and media ontologies, formatted in order to create a particular learning path for the understanding of the concept (Figure 20).

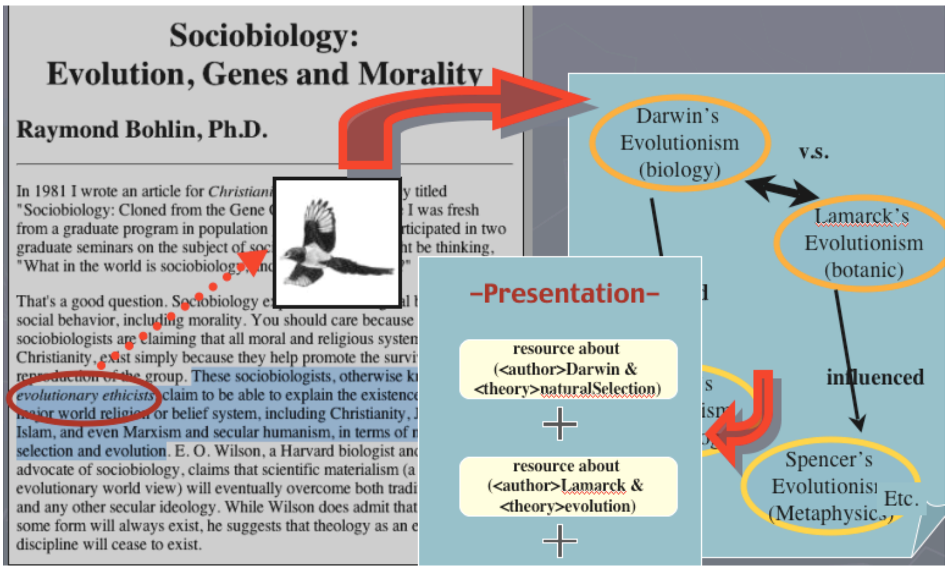

Figure 20 - Explanation of a concept through a learning web service

The kinds of learning narratives the system could support are, for example:

- **Critical explanation** of a concept / theory:
  Learning path that highlights the opposing theories, and the problems on which they are focused.
- **Contextualization** of a concept / theory:
  Learning path that shows associated information about the author, or the historical period, or other contemporary important theories in different research areas.
- **Production** of an author:
  Learning path that recollects all the activities and results of an author, and organizes them according to user's preferences (research areas, date, approach..).
- **Intellectual lineage** of an idea / theory:
  Learning path that follows the influence of ideas throughout the history of thought, across different areas and historical periods.

These narratives can be created thanks to cross reasoning algorithms between the learning narrative ontology and the domain one. We will show better in the next section how this happens.
From the pedagogical point of view, we reckon that this particular way of presenting narratives for learning (and in general, our overall approach) will foster the users' learning experience since the set and setting will instantiate some already described learning theories (of course, this is more of a guiding model for the moment, since the real outcome will need to be evaluated):

- **Learning is autonomous**:
  The user decides by himself when and what to learn; this pushes him/her towards the explicit formulation of learning goals, needs and strategies.
- **Learning is constructed**:
  The learning path starts from something that is already known (e.g., reading a paper on a familiar subject), and builds on it.
- **Learning is situated:**
  The specific context of the learning activity is the guarantee that the new knowledge does not remain 'abstract', i.e. detached from its use.
- **Learning becomes meta-learning**:
  The discovery of meaningful linkages between concepts makes the user perceive the potential 'semantic net' behind any single instance, and teaches him/her how to move unconventionally in order to learn new things.

5. System Description

Our main goal is the deployment of an educational tool, called from now on PhiloSURFical, that:
a) Supports the studying of a philosophical document, delivering on-the-fly philosophical resources organized into an explicatory learning narrative.
b) Allows the navigation of a large set of annotated philosophical resources, thanks to a peculiar conceptualization of the domain (ontology of philosophy), and delivers an automated structured presentation of a search result, drawing from both domain knowledge and narrative knowledge.

The two tasks are complementary, and benefit from the same core structure of the system, as we can see in the figure below. What can change, instead, is the entry point to the triggering of the semantic learning services described above.

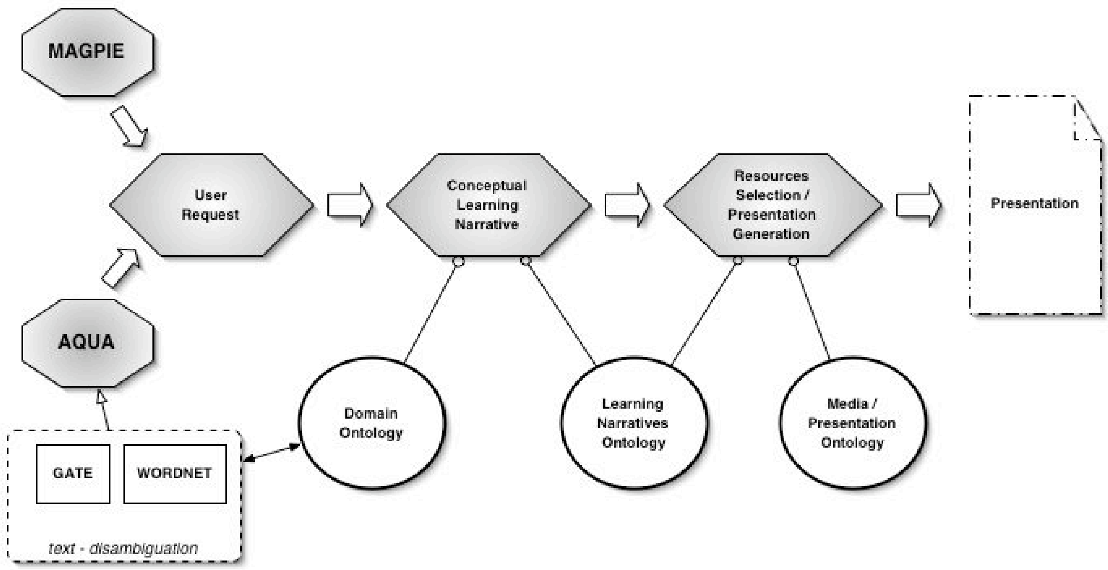

Figure 21 - PhiloSURFical: the system flowchart

In fact, the user can interact with the system as a pure web service, called through a browser plug-in such as Magpie, or he/she can directly query the knowledge base using an NLP interface such as AQUA [100]. In this second case, in addition to Gate [101] and WordNet [102], also the domain ontology is used in order to disambiguate the natural language question, since it provides the specific knowledge about philosophy.
Magpie and Aqua, therefore, constitute the modules that help the user create a query, or, more precisely, invoke a learning narrative. This is the <u>first</u> phase of the system.
The <u>second</u> one, instead, drawing from the domain and the learning narratives ontologies, performs a reasoning in order to match the user's request with the proper learning paths available. In other words, it examines the various possibilities of linking concepts and generates an abstract concept's route, corresponding to the most suitable learning narrative.
Finally, the <u>third</u> phase involves the transformation of this abstract connection of concepts into a real presentation. The resources, therefore, must be retrieved and organized following the learning narratives ontology. Moreover, since resources can be of different kind and format, it will be necessary to employ another ontology about

media and presentation structures. The collaborative work of these two ontologies will eventually create a coherent output (from both the semantic and the presentational point of views).
To sum up, these are the kind of ontologies employed, and some initial hints about their implementation:

- Domain ontology, that is, a philosophical one, which can be partially derived from the existing extension of WordNet for philosophy [103];
- Learning narratives ontology, which will make use of existing material on narratives, like [47], augmented with specific insights from the domain learning narratives we are going to define;
- Media/Presentation ontology, which will be constructed, after a detailed analysis of the kind of philosophical resources available on the Web, making use of much work already done in this direction [104] [105].

From the implementation point of view, the ontologies will be created using OCML, while the rest of the application will be deployed in Java and JSP for the web-interfaces. APIs to let Java and OCML communicate are already existing.

6. Domain Analysis and Formalization

This section presents the initial work done in order to construct the domain ontology of the PhiloSURFical system. The approach chosen for the engineering of the philosophical domain is of course influenced by the final aim of providing learning narratives to the user. Moreover, the following dimensions we will present as a breakdown of the domain have been proved to be valid also by an analysis of various philosophy books.

An ontology for philosophy can be seen as a categorization of the domain that should be, at the same time, quite precise and quite detached.
Precise in focusing on the key points that we can find throughout the philosophical work, the underground motifs that guide the questioning and the explicit places where the research has historically condensed.
Detached, since, in order to maintain a wider applicability, the categorization tries to be *a-philosophical* to the maximum level: it does not itself bring forward a philosophical standpoint (of course, at the extreme level, this is impossible) but its strength lies in its being a meta-philosophy.
This standpoint is clearly expressed by the difference in meaning of the concepts *systemic* and *systematic*. While the first one refers to an approach that tries to reduce everything to a single principle or set of principles, therefore explaining a whole set of phenomena as different manifestations of the same underlying reason, the second one refers to an approach that let things 'live in themselves', namely, it leaves things their specificity and does not try to reduce one to the other.

In doing so, we have imagined ourselves to be in a situation similar to that of a librarian who owns a giant amount of philosophical books, and wants to cleverly organize them. The final aim of this categorization, therefore, is to provide a high level semantic structure that allows intelligent navigation of philosophical resources.

In a similar vein to Dieberger and Frank [106], a potentially useful metaphor we can use to describe philosophy is to see it as a wide *territory* (figure 22), defined, firstly, by the needs of someone who has to go through it (e.g. a student).

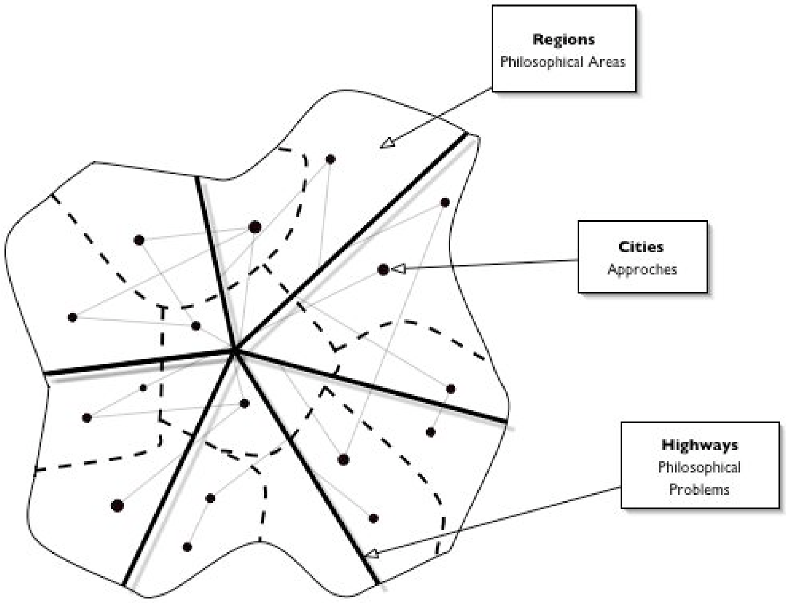

Figure 22 - The philosophical territory

These needs are the **highways** that give sense and direction within the territory, and correspond to the problems that guide the research and that give birth to the philosophical questioning. These dimensions can be defined as the basic philosophical **problems**, and their answers can be located, following the work of Schulz [107], throughout the entire history of philosophy (figure 23).

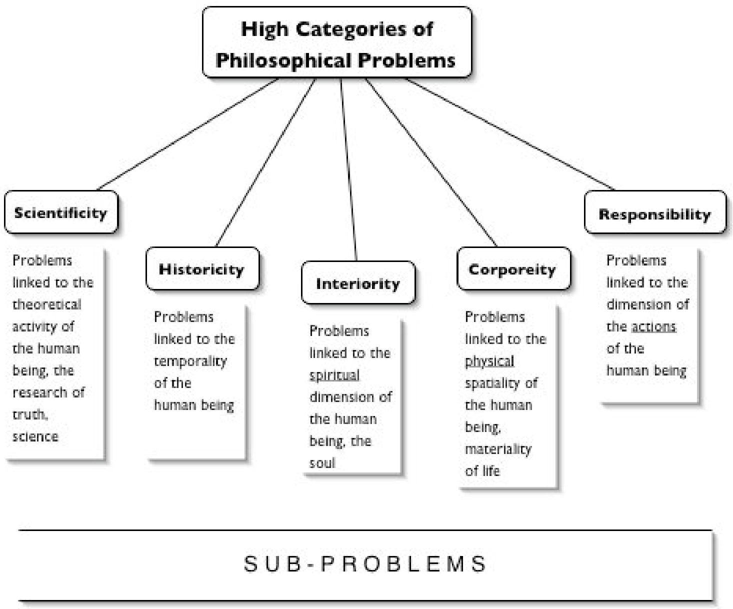

Figure 23 - The high-level philosophical problems

The strength of this approach relies in its being a-philosophical, in a sense. In fact, it starts from a normal person's experience, the everyday life, and from there it raises the philosophical departure points. The problems, therefore, are not yet *philosophical discussions*, but just the possible spark of them. Browsing through the problems is a way to connect philosophical resources in a quite detached and accessible way.

Within the territory, the highways (together with smaller roads - the sub problems) connect the different *regions*, and actually also define them. Following the initial metaphor, in fact, a region gathers around a set of communication channels, namely, around one or more problems.
Regions therefore stand for the institutionalized and historical ways to solve one or more problems, and correspond to the established philosophical **areas**. The same problem, in fact, can appear in different contexts and consequently also generates different solutions, depending on how it is tackled. An area gathers a knot of solutions (representations of the problem and of its resolution) that with time may become autonomous, and maintain their meaning independently of their "birth place".

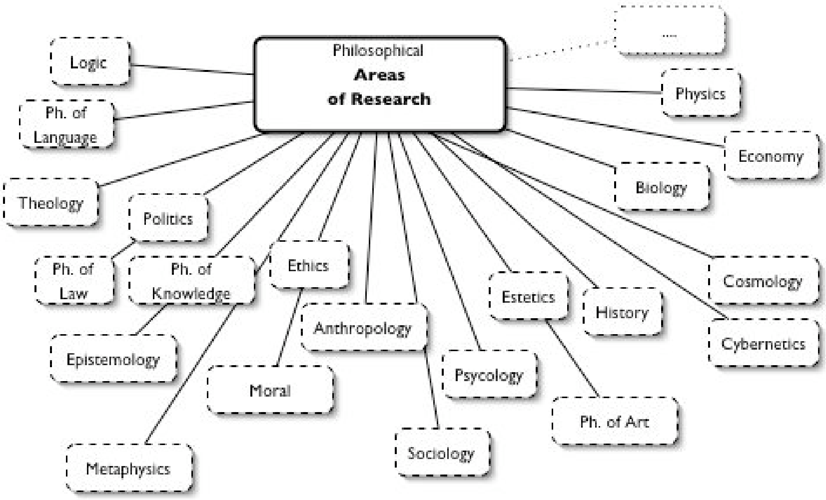

Figure 24 - The areas of research with which the philosophical work is involved

These solutions correspond to the philosophical **theories**. A theory is a constellation of concepts, namely a model, a representation of a recognized (philosophical) standpoint in the community. As such, it is directly related to a specific problem.
In fact, theories correspond to the other side of problems: they solve them and they are used in different areas (regions), therefore they should also be represented in a complementary way: in fact, we can look at them as the **vehicles** that move in the territory, along the highways.
That is, theories are the main vehicle we can use in order to navigate through the philosophical space: the evolution of a theory and its movement from one domain to another within the history of thought is the most powerful semantic navigation we can define.

Moreover, within the areas, we can recognize another different entity: the philosophical **approach**. An approach is defined as the application of a theory in a specific domain (thus, the theory by definition is related to more than one domain). Approaches correspond to the **cities** in the regions, since they can be similar to each other but still not the same, at the very least because they are instantiated in different areas.

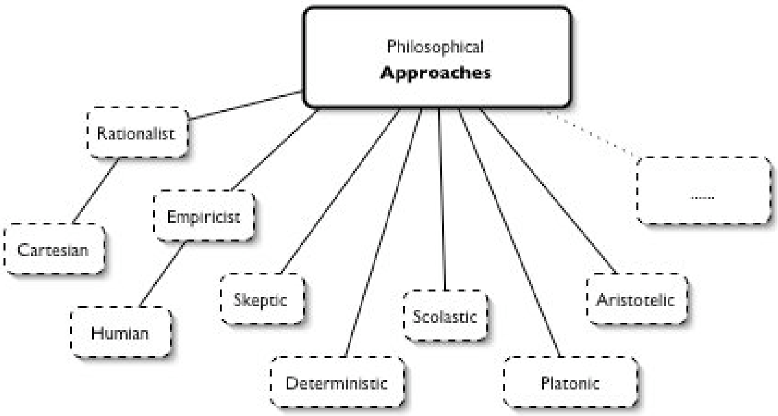

Figure 25 - The philosophical approaches

So, for example, within this framework, we can represent an author's conceptions throughout all his life as a path that goes through cities-approaches, regions-areas and implicitly is marked by being overlapping with the path of the highways-problems.

A particular **location** (Figure 26) in the philosophical territory is therefore defined in terms of a problematic field, a philosophical area and an approach (i.e. the instantiation of a theory). These dimensions allow an adequate initial mapping of the semantic position of any resource.

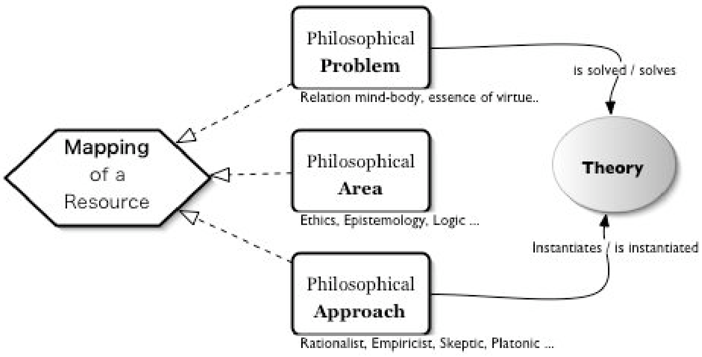

Figure 26 - The major dimensions of the mapping of a philosophical document

The entire generic semantic framework that has been presented until now, however, constitutes only a part of what is needed in order to efficiently browse philosophical resources. We can name this kind of knowledge *interpretative*, since it is defined by the person who annotates a document or by who inserts a conceptual schema. Eventually, this kind of knowledge is strictly subjective and relies on a person's standpoint and interpretation of a philosophical standpoint. In fact, for example, the correlation of a particular answer to the "mind-body" problem to the "ethic" research area is a subjective choice and interpretation of a source. The same source could be seen as the instantiation of the same problem in the "epistemological" area.

On the other side, there is the *factual* knowledge, which is the set of 'indubitable' information about authors and their works, for example that related to dates, places, publishers or historical periods. This kind of data is of course quite obvious and actually it is what constitutes the narrative backbone of the most common books about the history of philosophy, nonetheless it is still precious for us, since it can be used in conjunction with the interpretative knowledge, to generate interesting cross-narratives (for example, to show the evolution of a theory within a particular age).

This initial work towards the formalization of the philosophical domain is visually represented in figure 27, while in the Appendix 1 there is also the implementation of the ontology in OCML (an online updated version of the ontology is present on *www.kmi.open.ac.uk/people/mikele/philontology/*).

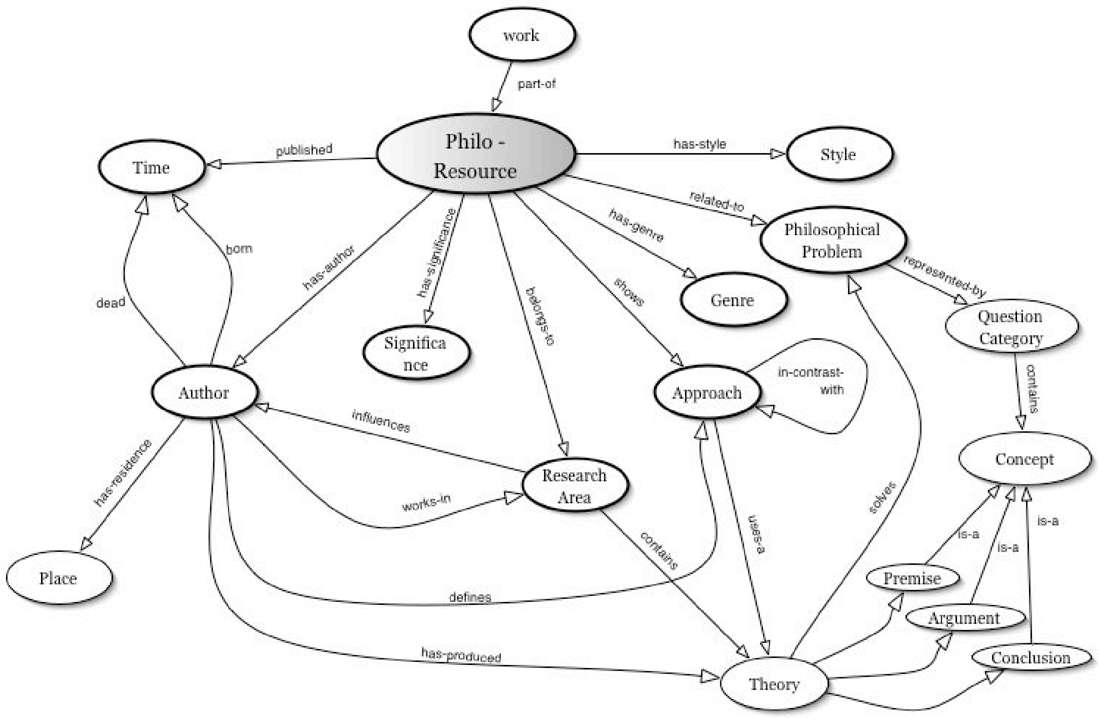

Figure 27 – The ontology for philosophy

7. Evaluation

The system will be evaluated along the following four points:

a) Validity of the ontological structures;
b) Coherence of the learning narratives;
c) Usability of the system;
d) Pedagogical efficiency.

For that regards the first two, we will strongly rely on domain experts such as high school and university teachers, in order to check the consistency and the representational power of the domain model we will develop.
The last two points, instead, will benefit from the analysis of the system's usage within an OU philosophy course. Apart from some generic usability methods we could employ, we will look for strategies in order to understand how much the new technologies have enhanced and facilitated the students' sense-making process of philosophical knowledge. Notoriously, the task of assessing the pedagogical value of a software system is a quite complicate matter (for the same variety of meanings people attribute to the process of learning, as we have briefly discussed in the first part of the review), we will thus consider in more detail this issue in the future, once the learning narratives and the system itself will be more defined.

8. Expected Contributions

The major outcomes of the research will produce at least the following contributions:

- An ontology to map the semantics of a philosophical resource, fostered by the validation of several experts in the field and with good possibilities of reuse within different scenarios;
- An ontology to point out the possible ways to browse, within an educational perspective, the semantic space defined by the previous ontology (namely, the learning narratives of the domain).
- A higher layer of this last narrative ontology, drawn from the analysis of similar narrative-creating applications in different domains, in order to define the abstract features of a generic learning narrative.
- An exemplificative implementation of the learning narratives' construction process in the philosophical domain, through a pilot study that dynamically recollects and composes some pre-annotated material.

9. Work Plan

The research will be carried out between September 2005 and September 2007, for a total of 23 months. The major tasks involved are the following:

- Domain ontology development
  [start] Oct 2005 [end] Dec 2005

- Annotation of a sample set of philosophical resources
  [start] Oct 2005 [end] Dec 2005
- Domain ontology evaluation
  [start] Nov 2005 [end] Feb 2006
- Definition and formalization of the possible learning narratives for the philosophical domain
  [start] Nov 2005 [end] Jan 2006
- Evaluation of the learning narratives
  [start] Dec 2005 [end] Feb 2006
- Detailed analysis of similar educational narratives supported by other systems, in other domains
  [start] Jan 2006 [end] Feb 2006
- Definition of an upper layer of the learning narratives ontology
  [start] Feb 2006 [end] Apr 2006
- Application development
  [start] Mar 2006 [end] Sept 2006
- Application evaluation
  [start] Sept 2006 [end] Dec 2006
- Thesis writing
  [start] Dec 2006 [end] July 2007
- Thesis revision
  [start] Jul 2007 [end] Sept 2007
- Thesis submission
  Sept 2007

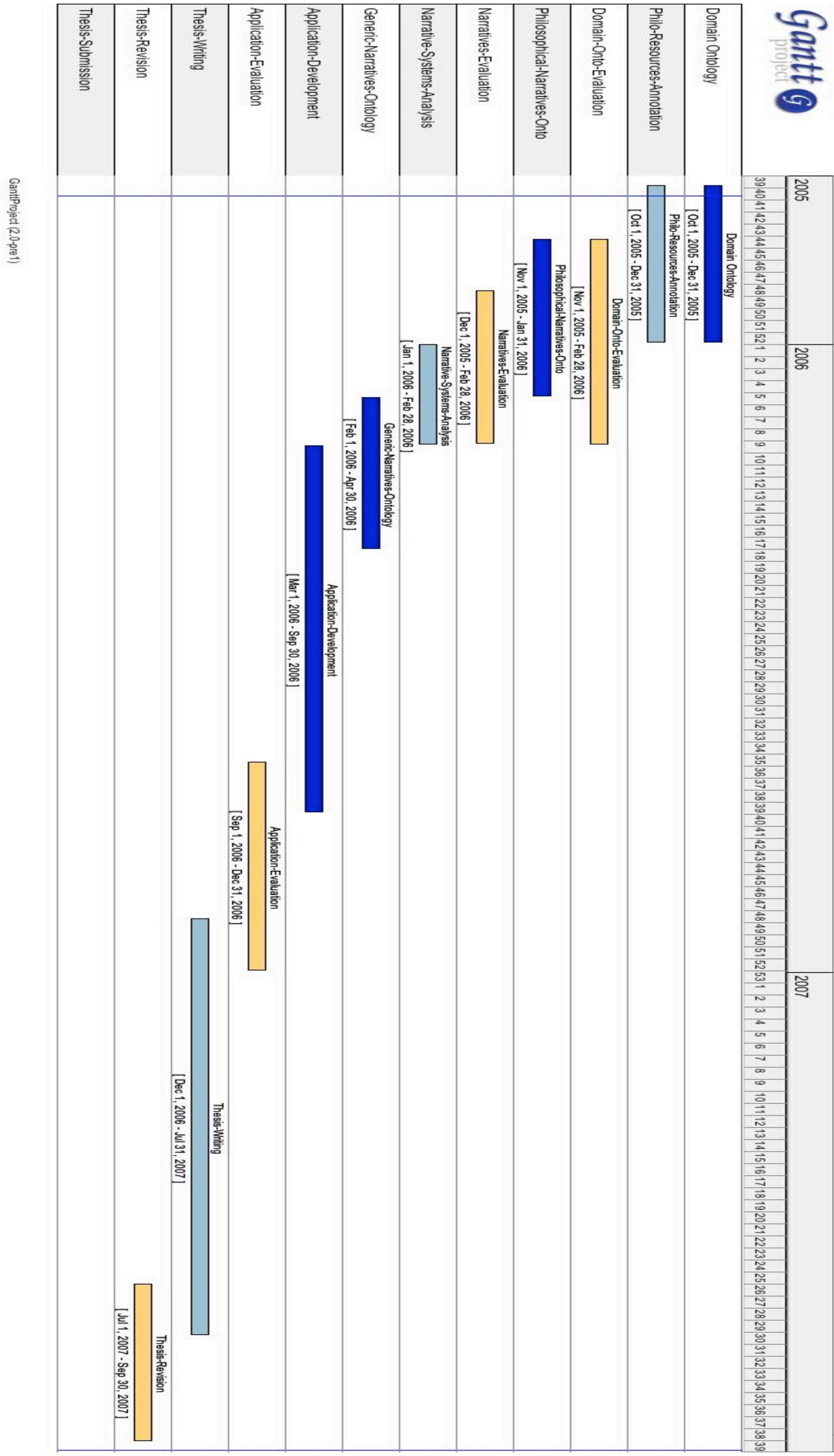

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Figure 28 – Work Plan

Appendix 1 – Initial OCML implementation of the ontology

```
;;; -*- Mode: LISP; Syntax: Common-lisp; Base: 10; Package: OCML;   -*-

(in-package "OCML")


(in-ontology philosophical-knowledge)

(def-class philosophical-thing ())

;;; these are abstract classes
(def-class ph-empirical-thing (philosophical-thing)
"Any physical entity related to the abstract entities -time is an exception" )

(def-class ph-theoretical-thing (philosophical-thing)
"All the abstract entities in the domain"  )

(def-class ph-pedagogical-thing (philosophical-thing)
"All the entities representing the instructional value of a philosophical resource"  )


;;;;;;;;;;;;;;;;;;;;;;;;;;;here the ph-empirical-thing starts

(def-class Person (ph-empirical-thing)
"Generic info about a person"
  ((has-name :type String)
   (has-gender :type Gender)
   (born :type Calendar-date)
   (dead :type Calendar-date)
   (has-lived :type Place)))

(def-class Gender (ph-empirical-thing))
(def-instance MALE gender)
(def-instance FEMALE gender)


(def-class Calendar-date (ph-empirical-thing)
 ((has-day :type number)
  (has-month :type number)
  (has-year :type number)))


(def-class Author (Person)
"Anybody who has published something"
 ((has-publication :type Publication :min-cardinality 1)
  (has-worked-in :type Institute)))
```

```
(def-class Place (ph-empirical-thing)
  ((has-name :type String)
   (has-country : type Country)))

(def-class Institute (Place)
  ((has-name :type String)))


(def-class Real-world-fact (ph-empirical-thing)
"Any state of things happening in the world"
  ((has-description :type String)))


(def-class Philosohical-resource (ph-empirical-thing)
"A book, a website, a video, a paper etc."
  ((has-author :type Author)
   (has-name :type String)
   (has-pedagogical-value :type ph-pedagogical-thing)))

(def-class Publication (Philosohical-resource)
  ((has-title :type String)
   (has-genre :type Genre)
   (has-style :type Style)
   (has-date-of-publication :type Calendar-date)
   (refers-to-publication :type Publication)))


(def-class Genre (ph-empirical-thing))

(def-class Dialogue (Genre))
(def-class Tractatus (Genre))
(def-class Essay (Genre))
(def-class Autobiography (Genre))
(def-class Meditation (Genre))

(def-class Style (ph-empirical-thing))

(def-class Argumentative (Style))
(def-class Dialectic (Style))
(def-class Polemic (Style))
(def-class Ironic (Style))
(def-class Assertive (Style))
(def-class Systematic (Style))
(def-class Apologetic (Style))
(def-class Metaphorical (Style))
(def-class Formal (Style))
(def-class Authoritarian (Style))
```

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;here the ph-theoretical-thing starts

(def-class problematic-area (ph-theoretical-thing)
 "A set of problems linked by different kind of relational schemas, such as analogy, derivation, etc.. For example, psycology, if treated as a problematic area, can gather problems tied to the mind, or the human behaviour. An important feature is that we can have links between two or more problematic areas: in Plato (myth of the cave) psycology, ph. of knowledge and politics - all intended as set of problems - are connected by a central theory."

  ((has-name :type String)
   (has-key-problems :type problem)
   (has-problem :type problem)
   (is-related-to :type problematic-area)))


(def-class problem (ph-theoretical-thing)
  "Question we are searching a solution for, which can be examined under different approaches (pespectives) and can have different solutions (theories) depending on them. A problem has necessarily (in theory, at least) more than one solution otherwise it would be a simple "question", similar to a theorem in a mathematical sense (that is, a question with only one answer determined by an exact procedure). Instead the problem, in a heuristical or research-sense, is a dilemma, a question with various (theoretically equivalent) solutions"

  ((is-expressed-by :type question)
   (is-generated-by :type Real-world-fact)
   (is-equivalent-to :type problem)
   (is-defined-by :type String)
   (belongs-to :type problematic-area)
   (is-related-to :type problem)
   (is-specified-by :type approach : min-cardinality 1 )
   (has-resolutive-method :type heuristic)
   (has-solution :type theory)))


(def-class question (ph-theoretical-thing)
"The problem formulation in the clearest, shortest and exhaustive manner"
  ((has-structure :type String)
   (has-content :type String)
   (has-key-concept :type concept)))


(def-class heuristic (ph-theoretical-thing))
```

```
(def-class heuristic-method (heuristic)
  "specific research technique, -procedure- for investigating, ex. syllogistic, dubitative,
demonstrative, deductive, inductive..."
  ((has-name :type String)))

(def-class heuristic-route (heuristic)
  "description of the effective -process- that takes to the problem's solution, the
unfolding of the process.."
  ((has-content :type String)
   (instantiates :type heuristic-method)
   (has-argumentative-knot :type argumentative-knot))


(def-class argumentative-knot (ph-theoretical-thing)
  "Focal point of the philosophical argumentation, where all the main argumentative
threads converge and meet. In fact, it is not our interest to map out all the
argumentative steps, but only the principals for they express the central force of a
philosophical thought"
  ((has-name :type String)
   (supports :type theory)
   (opposes :type theory)
   (is-related-to :type heuristic-route)
   (has-content :type String)))


(def-class theory (ph-theoretical-thing)
   "A systemic conceptual construction, with a coherent and organic architecture.
Differently from a scientific theory, it is not necessarily hypotetical and therefore it
does not need experimental verification"
  ((has-name :type String)
   (supports :type theory)
   (opposes :type theory)
   (is-related-to :type theory)
   (belongs-to :type school-of-thought)
   (is-produced-by :type heuristic)
   (assumes-principles :type String)
   (defines :type concept)
   (has-content :type String)
   (produces-conclusion : type String)))



(def-class concept (ph-theoretical-thing)
  ((has-name :type String)
   (has-relation :type concept)
   (is-defined-by :type theory : cardinality 1)
   (has-definition :type String)
   (has-the-same-meaning-as :type concept)))
```

```
(def-class approach (ph-theoretical-thing)
  "It's a standpoint, a criteria used to tackle a problem or to study a phenomena. For
example, I can look at the alienation problem within a gnoseological approach, a
metaphysical one or a political one"
  ((has-name :type String)
   (has-criteria :type criteria)
   (deals-with :type problematic-area)
   (uses-model :type model)))


(def-class criteria (ph-theoretical-thing)
  "Defines the sense of an approach, in relation to the classification of a problem
within an area"
  ((has-name :type String)
   (defines <problem> as belonging to a <problematic-area>)))


(def-class model (ph-theoretical-thing)
 "Defines the sense of an approach, in relation to the solution of the problem. It is the
school-of-thought as a methodological principle"
  ((has-name :type String)
   (refers-to :type theory)
   (refers-to :type school-of-thought)
   (defines :type theory)))


(def-class cultural-movement (ph-theoretical-thing)
 "General atmosphere present during some period - thus is broader than a school of
thought - for example during the illuminism there are different school of thoughts,
such as deism, materialism, etc. or during the romanticism there is an
irrationalist/spiritualist school opposed to a rationalist one"
  ((has-school :type school-of-thought)
   (has-name :type String)))


(def-class school-of-thought (ph-theoretical-thing)
"A set of thesis that share something and go towards the same direction, a trend of
opinions"

  ((has-name :type String)
   (has-opinion :type String)
   (related-to :type theory)
   (has-origin :type author)
   (influenced-by :type school-of-thought)
   (opposed-to :type school-of-thought)
   (born-within :type cultural-movement)))
```

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;here the ph-pedagogical-thing starts


(def-class historical-context ()
  ((has-name :type String)))
(def-class main-context (historical-context)
  ((has-content :type String)))
(def-class side-context (historical-context)
  ((has-content :type String)))

(def-class introduction ()
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)))

(def-class theme ()
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)))

(def-class sub-theme (theme)
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)
   (follows :type sub-theme)
   (preceeds :type sub-theme)))

(def-class widening-remark ()    ;;approfondimento
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)))

(def-class exercise ()
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)))

(def-class vocabulary-explanation ()
  ((has-explicandum :type String)
   (has-content :type String)
   (refers-to :type ph-theoretical-thing)))

(def-class conclusion ()
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)))

(def-class bibliography ()
  ((has-content :type String)
   (refers-to :type ph-theoretical-thing)))
```

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