E-Learning: An Assessment Tool Based on a Bayesian Approach

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Abstract - Assessment of student learning is an important task in a teaching and learning process. It has a strong influence on students' approaches to learning and their outcomes. But what is assessment? Assessment, in the context of education, is the process of characterizing what a student knows. The reasons to perform evaluation are quite varied, ranging from a need to informally understand student learning progress in a course to a need to characterize student expertise in a subject. Finding an appropriate and effective assessment approach is a central challenge in designing a tutoring approach. However, it sometimes happens that the assessment criteria and their corresponding weights are solely determined by the lecturers in charge and on the other hand an effective assessment program is extremely difficult to maintain as class sizes increase. The aim of this paper is the introduction of a tutoring approach based on the assessment results. This strategy is mainly developed for the supporting of the E-Learning formative process. The starting point of the proposed approach is the representation of the course knowledge domain by the use of the ontology formalism. In this way, by an original mapping strategy between ontology and Bayesian network, we can design a tool for the generation of adapted questionnaires in order to test the student's knowledge of every domain's subject. Analyzing the obtained results of the evaluation an intelligent tutoring system can help students offering an effective support to learning process and adapting their learning paths.

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1. INTRODUCTION

Our "information-oriented" society shows an increasing demand of life-long learning. In such framework, on-line learning is becoming a real solution that allows flexibility and quality in the learning process. In the last decade the evolution on educational technologies forced an extraordinary interest in new methods for delivering learning content to learners. Distance education represents today an effective way for supporting and sometimes substituting the traditional formative processes. However the role of technology has often been overestimated and on the other hand the amount of information students can obtain from the Internet is huge and they can easily be confused. Teachers can also be disconcerted by this quantity of contents and they are often unable to suggest the correct contents to their students. In the open scientific literature, it is widely recognized that an important factor of this success is related with the capability of customizing the learning process for the specific needs of a given learner. This feature is still far to have been reached and there is a real interest for investigating new approaches and tools to adapt the formative process on specific individual needs. In this field the assessment phase is acquiring a strategic interest. In fact, assessment is an important and difficult task in the whole teaching and learning process [1][2]. It has a strong influence on students' approaches to learning and their learning outcomes. An effective assessment program is extremely difficult to maintain as class sizes increase. One recent analysis [EXC00] showed that, for classes in excess of 100 students, the instructor devoted more time to preparing and marking just the final examination than to all teaching duties: lecturing, lecture preparation, tutorials, etc. Other studies have shown that the assessment system is the main influence on how students structure their learning, determining both their effort and their focus [MIL74], [SNY71]. Further, less assessment entails less feedback to students, and for large classes feedback may be delayed significantly. The importance of prompt feedback is well established [FRE87], [MEH98]. One landmark study concluded that "formative assessment is an essential component of classroom work. We know of no other way of raising standards for which such a strong prima facie case can be made" [BLA98].

Traditionally assessment activity has been seen like task aside of the e-learning process and there is a danger in focusing research on assessment specifically, as this tends to isolate the assessment process from teaching and learning in general [BAR05]. This is a not effective approach: the evaluation should be one of the first considerations of design when you prepare an online course, integrating it in the program and not considered by apart [KEN00]. On the other hand the implementation of an effectiveness on-line evaluation strategy can be very difficult. It is very common opinion that the assessment phase is the weak point in the e-learning process. There are two problems in this phase. The first one is related to the concept of virtual identity (a typical problem in the internet world). The latter expresses the difficulty of teacher in the evaluation of student's knowledge on the basis of few data. Many of currently existing E-Learning assessment systems focus on simple assessment strategies, e.g. only on single or multiple-choice questions (MCQ) with several answers, and radio-buttons to select the correct answer. Furthermore most of them are unable to support the different needs of individual users and focus mainly on the assessment of the "average user". In this way teachers can give only a mere quantitative evaluation of students' knowledge and cannot fill in the gaps in their learning approach. In particular teacher cannot know if the proposed learning path or the teaching approach is really effective for students. Assessment provides an effective method to gather information about student's learning and it is a good starting point in order to arrange feedback's strategy. Finding an appropriate assessment tool is a central challenge in designing an assessment approach [4], [5]. The difficulty arises because of the diversity of learning objectives [4], the diversity in what counts as evidence of learning, the diversity of tools available, the varying resources available, and the varying assessment contexts. One way to address these various assessment goals and challenges is through the use of concept maps [RIC98][TUR00], which are node and arc representations of the relationships among concepts. Concept maps represent a valuable assessment tool because they provide a means to capture and represent student knowledge and are particularly effective for representing the organization that students see among concepts [SHU02]. So starting from this general framework in this paper we describe our system for assessment and tutoring based on Ontology formalism (the generalization of concept maps) and metadata standards. The concept of ontology was taken from philosophy where it means a systematic explanation of being. In recent years, however, this concept has been introduced and used in different contexts, thereby playing a predominant role in knowledge engineering and in artificial intelligence [7]. In E-Learning field ontology can easily manage the knowledge domain of a course allowing a more detailed organization and adaptation of student's learning path. This task can be accomplished through the combined use of the ontology formalism and the user and learning object through metadata standard [8]. Ontology explains in a generic and intuitive way the organization of a course. In particular teacher can delineate the course's subjects and the relationships between the same one. In the next section of this paper we give more details about ontology. In this paper we represent ontology through Bayesian Networks formalism because in this way we can depict and estimate the preparatory links between the various subjects belonging to knowledge domain. In this way it is easier to understand the real knowledge shortage of students [9]. In fact teacher or an Intelligent Tutoring System can build and analyze questionnaires keeping in mind the reference ontology and the relationships between the subjects. In this paper we design and implement a tool that arranges the best assessment strategy and adapts the best learning path according to the information inferred by the analysis of questionnaires. Our tool can test the knowledge of students on every subject of ontology adopting various approaches. For example it can examine deeply some subject rather than other if student shows some lacks in certain subjects. The Bayesian approach, used for the representation of ontology, allows quantizing the probability of correct answer of students in a particular subject. In this way tool can propose to the student the question with the lower (or higher) probabilities of correct answer. At the end of the assessment student's profile is updated and at the same time tool proposes the most suitable learning objects in order to improve their knowledge. The paper is organized as follows: in Section 2, we provide the motivations and the details of the proposed assessment tool. In particular we give some details on ontology and their mapping through Bayesian Networks. In section 3 we describe the proposed approach. In section 4 the experimental results are reported. Finally, in the last section we draw conclusions and indicate future directions of our research.

2. AN ONTOLOGY APPROACH FOR SUPPORTING ASSESSMENT PHASE

Some of the tasks that an E-Learning platform should carry out are to allow people to find, evaluate and acquire adapted learning objects. These activities are common and easy to carry out in traditional learning processes; however, we can not say the same when new technologies are used. While designing and organizing a course, a teacher has to choose the most appropriate training contents: this digital contents' selection presents notable difficulties, also due to the huge amount of information available, of which only a minimum part really meets teachers' needs. The possibility of accessing to contents that could be useless or not related to the subjects of interest is considerable. A solution to these problems derives from the ever more detailed description of each training contents, a process known in literature as process of creating metadata. Metadata is descriptive information and is data about data [10]. The E-Learning industry is concerned with establishing rules to be commonly used in the process of creating metadata and, consequently, in describing contents, users, ontology and course structure. In particular the use of standardized metadata allows current E-Learning platforms to integrate new and more powerful services. In fact, in addition to reusability and sharing of training resources with other platforms, it is possible to design and implement "intelligent" services able to help students and teachers during the formative process. These services can add value to an E-Learning platform and guarantee an improvement in the pedagogical quality of the training process and adapt the learning path of every student. One of the most important services is the student's tracking: the selection, collection and analysis of a set of parameters of students' learning process that are essential for an effective teaching process organization. On the other hand in this framework a very important role is played by the assessment phase. Assessment gives to the learning environment the most direct information about the student's knowledge. The best assessment approach provides questionnaires that are built dynamically on the basis of the student model. Questions have to cover the topics most recently completed, as well as those that should be reviewed. Each question has a level of difficulty, which is also used in the updating phase of student model. Correctly answering a harder question demonstrates greater ability than correctly answering an easier one [11]. The assessment framework combines researches from two major research disciplines: adaptive educational hypermedia and semantic web technologies. Research in adaptive educational hypermedia has ascertained several techniques for adaptation [12]. These techniques can be divided into two categories: navigational level adaptation in which the learner is provided with a set of recommended links, and content level adaptation, which selects the text fragments that have to be assembled together for a specific user need. Through combining both techniques, the learner will be provided with a flexible learning process. It is worth noting that the assessment framework works at its best when it provides the learner with two kinds of content: learning content, containing the courses and their different sections, and assessment content, containing the tests for evaluation of the learner knowledge. During the learning process, a dynamic selection and presentation of both contents have to be accomplished. We have to underline that conceptualizing the learning process to its basic elements, we can identify at last the following elements [BAR05]:

- The educational material to be taught by the teacher
- The teaching and learning activities
- The assessment activity to measure the student learning
- The report of the score results given by the teachers to the students

As we can note, the tests and evaluations not only are an integral part of the learning process, but also is an element that complete and close a circular activity, contributing as a feedback source for: the users (giving the scores and feedback), for the instructors (by giving support and feedback) and for the instructional designer (to update the contents of the learning system) as well. This circular conceptualization of the learning process allow us to see the significance of the assessment because it helps to the adaptation of the system by setting a new user knowledge level, evaluating and determining new learning profiles, assign the user grades and, in consequence, performing user content re-adaptation.

In general the previously described framework can be implemented by the use of tools depicted in figure 1.

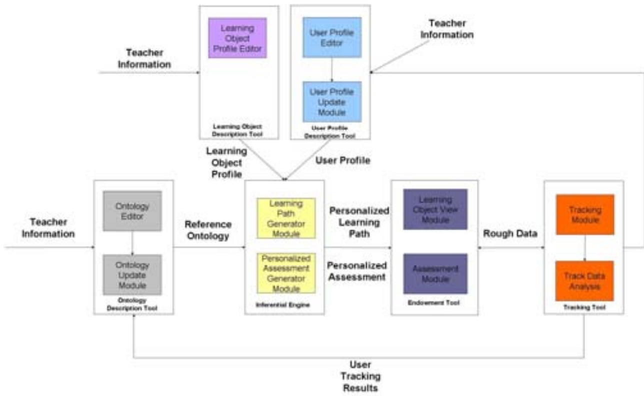

Figure 1: Student Learning Cycle

The previous schema could be considered as a general schema of a modern E-Learning environment. In the previous picture we have the following blocks:

- Ontology Description Tool: this tool allows the ontology definition. In particular teacher can build the reference ontology for a course but also introduce various levels of details for the same one. In fact for the same course teacher can define a basic ontology and, by the introduction of new topics, some advanced ontology. The Ontology Update Module can update the ontology and select one of the advanced ontology according to the information acquired during the learning phase.
- Learning Object Description Tool: this tool allows the description, according to the "de facto" standards that are in literature, of learning objects. This description could be used by the inferential engine in order to create the best personalized learning path.
- User Profile Description Tool: this tool allows the description, according to the "de facto" standards that are in literature, of the user learning model. It contains two distinct sub-models, one for representing the learner's state of knowledge, and another one for representing learner's cognitive characteristics and learning preferences (such as learning style, working memory capacity etc.). This distinction is made due to the fact that the first model (Learner Knowledge Space) can be frequently updated. On the other hand, learner's cognitive characteristics and learning preferences are more static and have the same property values during a significant learning period.
- Inferential Engine: this tool has the aim to build the personalized learning path and the personalized assessment. In particular by the combined use of student profile and learning object descriptions a personalized learning path could be built and updated.
- Endowment Tool: by the use of this tool students can access to learning object and collaborative services as chat, forum, e-mail and so on.

Tracking Tool: This module observes the student activity during his period of studying. The two main targets of this methodology are:

- to maintain up-to-date information about student model's parameters (as for example the studying time, the number and the average time used to study a learning resource, preparation level, level of interest for determined type of media

- to provide an evaluation of the learner action related to his entire learning path by using information acquired during the observation activity. In this way it is possible to evaluate the learner performance by providing a global assessment usually based only on the final test mark.

In this paper the attention is on the assessment phase and in particular in the designing of an adapted assessment generator. In the next section this approach is introduced and described in its main features. In particular the methodology for the description of ontology by the use of Bayesian Network is showed and how it is a good starting point for the introduction of new and smart services that will be introduced in the third section.

2.1. ONTOLOGY

The concept of ontology is originally taken from philosophy where it means a systematic explanation of being. In recent years, however, this concept has been introduced and used in different contexts, thereby playing a predominant role in knowledge engineering and in artificial intelligence [7bis]. In 1991, Neches stated that ontology defines the basic terms and relations comprising the vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary [1bis]. Later on, Gruber, in the context of knowledge sharing, used the term to refer to an explicit specification of a conceptualization [8bis]. Mizoguchi summarized the merits of ontology as following: "Ontology provides a common vocabulary, and an explication of what has been often left implicit". According to Mizoguchi, the systematization of knowledge and the standardization constitutes the backbone of knowledge within a knowledge-based system. He also pointed out that a metamodel functionality specifies the concepts and relations among them, which are used as the main building blocks. Ontology engineering has contributed several interesting aspects to modeling. Maedche and Staab [27bis] stressed that ontologies could be considered as "metadata schemas providing a controlled vocabulary of concepts". An interesting clarification of the philosophical term ontology is provided by [29bis]. This paper summarized several common definitions of ontology and tried to elaborate further the main consideration that ontology is a specification of a conceptualization. According to this approach ontology could be depicted as a philosophical discipline:

- An informal conceptual system
- A formal semantic account
- A specification of a "conceptualization"
- As a representation of a conceptual system via a logical theory
    - o characterized by specific formal properties
    - o characterized only by its specific purposes
- As the vocabulary used by a logical theory
- As a (meta-level) specification of a logical theory

In the field of computer science, ontology represents a tool useful to the learning processes that are typical of artificial intelligence. In fact, the use of ontologies is rapidly growing thanks to the significant functions they are carrying out in information systems, semantic web and knowledge-based systems. The current attention to ontologies paid by the AI community also arises from its recent interest in content theories, an interest that is greater than the one in mechanism theories. In this regard, Chandrasekaran [7bis] makes a clear distinction between these theories by asserting that, though mechanisms are important since they are proposed as the secret of making intelligent machines, they can not do much without a good content theory of the domain on which they have to work. Besides, once a good content theory is available, many different mechanisms can be used to implement effective systems, all using essentially the same content. Following this point of view, ontologies are content theories, since their principal contribution consists in identifying specific classes of objects and relations existing in some knowledge domains [9bis]. Ontological analysis, therefore, clarifies knowledge structures: given a domain, its ontology represents the heart of any knowledge representation system for that domain. Another reason for creating and developing ontology is the possibility of sharing and reusing knowledge domain among people or software agents. In general, ontology is a complex structure made up of a series of elements, each of which is composed of a kind of Relation and a series of related Concepts. Ontology in the context of e-learning means that we the presence of an (unspecified) conceptual system is admitted (a common hypothesis in E-Learning implementations). For example, as far as concerning University Courses, by means of an ontology built by the teacher, it will be possible to describe the knowledge domain, the subjects constituting it, the relations among the various subjects, as well as methodologies and means with which they are presented. These explicit specifications help users to understand what specific terms signify in a given domain [2bis] and reduce terminological and conceptual ambiguity. The content of an ontology depends both on the amount of information and on the degree of formality that is used to express it. Generally, two main types of ontologies are distinguished: lightweight and heavyweight [3bis]. A lightweight ontology is a structured representation of knowledge, which ranges from a simple enumeration of terms to a graph or taxonomy where the concepts are arranged in a hierarchy with a simple (specialization, is-a) relationship between them. Heavyweight ontology adds more meaning to this structure by providing axioms and broader descriptions of the knowledge. In this paper, the lightweight approach is adopted according to this definition of ontology: "ontology may take a variety of forms, but it will necessarily include a vocabulary of terms and some specification of their meaning. This includes definitions and an indication of how concepts are inter-related which collectively impose a structure on the domain and constrain the possible interpretations of terms" [10bis]. In the next section an approach to the representation of ontology by the use of Bayesian networks formalism is showed

2.2. ONTOLOGY AND BAYESIAN NETWORKS

As previously said in this section, how Bayesian Networks can be used "to map" and "to represent" ontology is described. Bayesian Networks have been successfully used to model knowledge under conditions of uncertainty within expert systems, and methods have been developed from data combination and expert system knowledge in order to learn them [11]. Bayesian Networks represent a "hot" topic in the research field; the interested reader can find some interesting good surveys in [12][13]. In this paper a key role is played by the learning process of Bayesian Networks that shows two important advantages: firstly, it is easy to encode knowledge of an expert and such knowledge can be used to improve learning efficiency and accuracy. Secondly, nodes and arcs of the learned Bayesian network are recognizable links and causal relationships. So users can understand and exploit more easily the knowledge encoded in the representation. A Bayesian network is a graph-based model encoding the joint probability distribution of a set of random variables $\mathbf{X=\{X_1, \ldots, X_n\}}$. It is composed by:

- A directed acyclic graph S (called structure) where each node is associated with one random variable $\mathbf{X_i}$ and each arc represents the conditional dependence among the nodes that it joins
- A set P of local probability distributions, each of which is associated with a random variable $\mathbf{X_i}$ and conditioned by the variables corresponding to the source nodes of the arcs entering the node with which $\mathbf{X_i}$ is associated. The lack of an arc between two nodes implies conditional independence. On the other hand, the presence of an arc from the node $\mathbf{X_i}$ to the node $\mathbf{X_j}$ represents that $\mathbf{X_i}$ is considered a direct cause of $\mathbf{X_j}$.

Given a structure S and the local probability distributions of each node p(X|$\mathbf{Pa_i}$), where $\mathbf{Pa_i}$ represents the set of parent nodes of $\mathbf{X_j}$, the joint probability distribution p($\mathbf{X}$) is obtained from: $p(\mathbf{X}) = \prod \mathbf{p}(\mathbf{X_i} | \mathbf{Pa_i})$ with i=1, …, n. So the couple (S, P) encodes p($\mathbf{X}$) unequivocally (on the hypothesis of conditional independence of the $\mathbf{X_j}$ given the) [11].

In order to build a Bayesian Network for a given set of variables, some arcs from the causal states to the other ones that represent their direct effects obtaining a network that accurately describes the conditional independence relations among the variables have to be defined. The aim of this paper is the introduction of an algorithm, based on the formalism of the Bayesian networks, able to infer the propaedeutic relationships among different subjects (in other terms the ontology) belonging to the knowledge domain of university curricula. The first step of this algorithm is the introduction of a mapping between Ontology and Bayesian Network. In our ontology model, nodes represent the subjects belonging to the knowledge domain (the course) while the arcs mean a propaedeutic relationship among the nodes. This ontology graph can be mapped in a Bayesian Network in the following way: the Bayesian Network nodes model the subjects belonging to the course Knowledge Domain and the knowledge of subject by students while arcs in the same way mean the propaedeutic relationships among the nodes. Given the previous mapping strategy, the aim is to define the ontology used by a teacher in his/her course. Obviously, data type and data set for this approach have to be defined. As previously said, student's answers to the evaluation tests represent a source of implicit evidence, because teachers through the end-of-course evaluation tests not only assess student's knowledge for every subject, but describe the course ontology and outline the propaedeutic aspects that relate subjects each other.

3. THE PROPOSED SYSTEM

In this section the detailed architecture of the proposed assessment tool, named Virtual Teacher, and the assessment and tutoring strategies are described. As previously said the aim is to design a tool for assessment able to support in an effective way students and teachers during the learning process.

The tool was designed analyzing the main needs of students and teachers. From a technological point of view it respects these constraints derived from web usability theory [NIE01]:

- Web based approach
- Aesthetic and minimalist design
- Flexibility and efficiency of use
- Help users recognize, diagnose, and recover from errors.

The design phase was conducted according to the UML approach and in particular the Use Case Diagrams, the Sequence Diagrams and the E-R Diagrams was produced. So the actors of the system and the use cases was pointed out. We identified three typologies of actors in the system: Administrator, Teacher and Student defining their roles and tasks can be summarized:

- Administrator: this actor can introduce and define new courses, students, teachers and manage the accesses to the tool
- Teacher: this actor can design the reference ontology, describe the learning objects and the questions linked to the nodes, and so the course

topics, of ontology. Teachers can also arrange reports on students learning process in order to better supervise their progress and support them.

- Student: this actor can use tool in three different ways: Exam, Normal and Bayesian test. In the Exam way Student has to solve a classical final test. At the end of the exam the system produces a report analyzing the performance of student in every subject. The Normal test approach can be used by Student during his learning path. The main aim of this service is to support Student to learn better the various learning objects. The more interesting service offered by our tool is the Bayesian test. This service makes the most of the matching between ontology and Bayesian Network. The first step is the introduction of a mapping strategy between Ontology and Bayesian Network. As said in the previous sections in the proposed ontology model nodes represent the subjects belonging to the knowledge domain of the course and the arcs mean a preparatory relationship among the nodes. In this way we can map the ontology graph in a Bayesian Network in the following way: the nodes of Bayesian Network model the subjects belonging to the course while the states (that are two: yes and not) of nodes represent the knowledge of student in the subject. The arcs mean the propaedeutical relationships among the nodes. So a node of Bayesian Network-ontology represents the Knowledge domain of a course and quantizes, by the use of the Bayesian rules, Student knowledge of this node-topic. When student accesses to the Bayesian Service the system select a set of questions associated to every network node. At the end of this first phase system, through a Bayesian approach infers what subjects the students knows better than others. In fact through the Bayesian analysis the system can measure the percentage of correct answer in a subject. In particular it can predict the percentage of correct answer to a subject after a correct (or not) answer to questions related to propaedeutic subjects. At this point it can apply various strategies: for example it can select and propose to the student the question with the smaller percentage of correct answer. At the end of Bayesian test a detailed report on the knowledge of student in the various subjects is sent to teacher and to student himself. In particular after the Bayesian test the system proposes to the student some learning object for deepening some subjects. At the same time tool proposes to the teacher a periodic report with the analysis of performances of various students in every topic. In this way teacher can understand easily where students need more help. At the end of Bayesian Test the system updates student user profile and builds its new adapted learning path.

Tool was developed using open source frameworks as PHP language, mySql Server and the web server Apache. Students have to use only a common web browser in order to access to tool services, in this way the system portability is insured. In the server side some modules, in particular the Bayesian inferential engine, were developed in Java.

4. EXPERIMENTAL RESULTS

In order to test the effectiveness of our tool we used it during the course of Introduction to Computer Science at Foreign Literature and Language Faculty of University of Salerno. This course is composed by seven modules: Introduction to PC Architecture, Introduction to Operative System, Microsoft Word, Microsoft Excel, Microsoft Access, Microsoft Power Point, Internet. The course was divided in modules, one for each topic, that contain didactic units that are composed by learning objects. Students can test their knowledge level at the end of every didactic units. In order to access at the next module students have to pass the Bayesian Assessment Phase referred to the didactic module. If the result of the test is positive then he can access to a study in depth module and according to the obtained result his profile and learning path is updated. In the case of negative result student has to study a supporting module, tailored on his didactic gaps and to sustain a new test. According to the new obtained result his profile and learning path is updated. The organization of every module can be so depicted (figure 3).

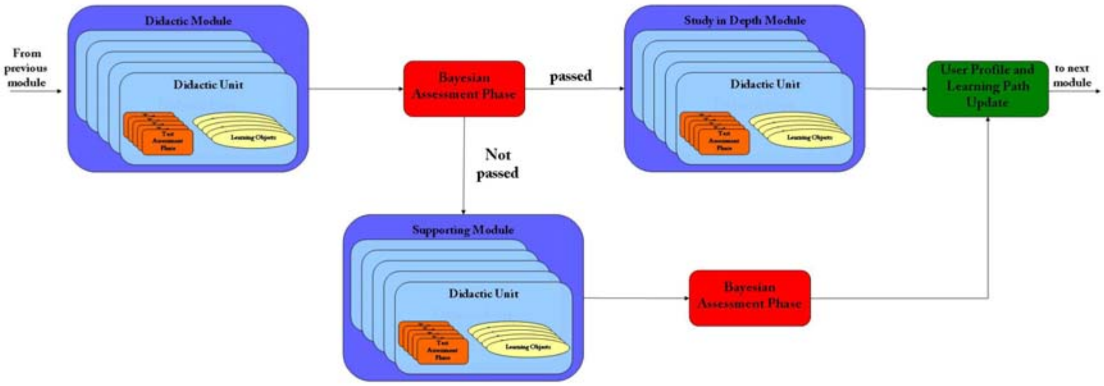

Figure 3: Organization of every module

On the basis of the considerations of previous section, teacher designed the reference ontology. Each node of the networks has two states and shows the probability that a generic learner knows the subject associated with the same node. We have supposed that each node can assume only the following two states (random Bernoullian variable): state 'Yes': complete knowledge of the subject and state 'Not': total ignorance on the subject. The student level of knowledge could be evaluated on the basis of the answers given to the questions (a set of questions is proposed for each subject). At the end of the course students have to get through a final examination's test composed by forty questions. The questions belong to every subject of knowledge domain.

The number of student's course was about 300 and at the starting of the course we arranged them in six group (named A, B, C, D, E and F). The first three groups had a classical support to course activities and used only the normal test approach while the second one used also all functionalities of the tool as didactic support. At the beginning of the course teachers designed every module's ontology in order to organize the contents. In particular an assessment entry test was realized with the aim to measure the starting knowledge level of students. The results are in the table 1.

	A Group	B Group	C Group	D Group	E Group	F Group
0-10	11	10	12	7	9	8
11-15	11	10	8	12	17	11
16-20	12	11	12	13	11	12
21-25	6	12	10	14	5	12
26-28	7	4	6	3	5	4
29-30	3	3	2	1	3	3
Average Level	15,96	15,98	14.46	15.52	13.36	16.08

Table 1: Results of Assessment Tool. The meaning of range is: [0-10]: very poor knowledge, [11-15]: poor knowledge, [16-20]: medium knowledge, [21-25]: good knowledge, [26-30]: very good knowledge

At the same time students filled also the ILS questionnaire [] in order to get other information about their learning style. The aim of this test is to allow a first description of student through a metadata structure. These information are essential in the definition of user model and, in particular, in the User Profile an Learning path update phase. In this phase is used the approach defined in the paper []. At this point the system organized for students of each groups a personalized learning path. In particular it selects the most suitable contents through a matching between the metadata of learning objects and the description of the student according to the strategy of []. As previously said during the course the students of the six groups attended to the lessons and used the assessment tool. In particular students of A, B and C group at the end of every module sustained a Bayesian Test, while the other groups had a traditional support. At the end of course students had their final course exam. In table 2 and 3 the obtained results are depicted:

	A Group	B Group	C Group	D Group	E Group	F Group
0-10	**2**	**2**	**7**	**4**	**8**	**2**
11-15	**1**	**5**	**7**	**12**	**5**	**5**
16-20	**9**	**8**	**6**	**11**	**11**	**7**
21-25	**20**	**16**	**6**	**12**	**9**	**19**
26-28	**11**	**10**	**14**	**5**	**11**	**10**
29-30	**7**	**9**	**10**	**6**	**6**	**7**
Average Level	23,28	15,98	14.46	15.52	13.36	16.08

Blue Group		***Red Group***	
Final Test	***Students***	***Final Test***	***Students***
0-10	*4*	*0-10*	*3*
11-15	*9*	*11-15*	*5*
16-20	*8*	*16-20*	*6*
21-25	*10*	*21-25*	*12*
26-30	*5*	*26-30*	*9*
Total	*36*	*Total*	*35*

Table 2: Results of Final Test

If we analyze the difference between the assessment and the final exam (table 1 and 2) we can note that the percentage of students that get through the assessment test is 37% in the red group and 42% in the blue group while in the case of the final examination the percentage is 77% in the red group and 64% in the blue group. We can note as more students of red group get through the final exam and improve their performance respect the assessment test (about 40%). In particular we can note that the students of the blue group has a minor improvement (about 22%) than the students of the red group. At the same time the percentage of red group's students that have a mark in the range 26-30 is higher than in the case of blue group: 26% to 8%. In order to collect more information about the effectiveness of our tool at the end of course we submitted a questionnaire to every student. In the questionnaire we asked the effectiveness of Bayesian test and of learning objects furnished by system at the end of the test. The 87 % of students said that the support of Virtual Teacher tool was very important in the learning process. In particular, the 73% of students declared that the supporting learning object helped them in a better knowledge of the various subjects.

5. CONCLUSION

In this paper we proposed a tool for the assessment and tutoring of students during a learning process. This is based on the use of ontology and Bayesian Network. In particular through the matching between ontology and Bayesian Network our tool allow an effective tutoring and a better adaptation of learning path to demands of students. The assessment based on Bayesian approach allows a deeper analysis of student's knowledge. The first experimental results seem to confirm our approach. As a future step of our research we intend to evaluate the performance of the proposed system when some students' tracking strategies are used.

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