Abstract—The introduction of information and communication technologies in medical curricula has created high expectations for education quality improvements over the last decade. To exploit technological advances in practice, a number of tools and environments have emerged allowing for learning processes and content management, as well as, student and teacher collaboration over the web. However, to be in a position to fully exploit the benefits of technology in a complex context such as that of medical education, one needs to fuse learning theories and teaching approaches with e-learning environments, which however, enable the web collaboration of teachers under the use of educational standards. In this paper, a prototype virtual collaboration environment for medical education is illustrated which utilizes an earlier proposed teaching framework based on taxonomies that, however, takes into account educational standards and standardized content specifications. The use of the system is demonstrated through a telecardiology example, while intelligent extensions of the system are discussed.

Educational technology, intelligent creation of SCORM content package, didactic instructions, Healthcare LOM, e-learning standards

I. INTRODUCTION

In recent years, advances in information and communication technology have acted as catalysts for significant developments in all sectors of science, economy and society. This practice is reinforced by active support and funding from bodies such as the European Union and local governments. Specifically, the European Council in its Lisbon meeting in March 2000 set forth the European policy for an information and knowledge-based society, stressing the need to encompass the emerging technological revolution and change in the exchange of knowledge affecting all institutions and various aspects of the society [1].

Within this context, higher education is increasingly employing information and communication technologies to support teaching, develop alternative forms for education delivery and accommodate the emerging trend in education that shifts attention from “teaching” to “learning”. Distance learning programs, integrated content and learning management systems, even virtual universities are indicative examples of this emergent information technology enabled educational era.

Medical education specifically is drawing much attention, due to its particular characteristics. Firstly, it is a field that encompasses not only the fundamental issue of education, but also the sensitive issue of health and health care services. Furthermore, education in medicine is multidisciplinary and rather long, involving a good number of academic years and extending to life-long continuing updating and learning. Additionally, medical education is traditionally based on a two-fold model: theoretical instruction based on textbooks and clinical practice with one-to-one interaction. Finally, one should stress the current enormous expansion in medical and biomedical knowledge, which constitutes a fundamental challenge in medical education [2].

Thus, medical academic institutions are increasingly required to invest in order to enrich their curricula by developing overspecialized courses and corresponding educational content. It is evident that such an overspecialized expertise cannot be readily available in any medical academic institution, thus external experts have to be involved. More-over it cannot be easily available for professional medical doctors in their life-long continuous education. Although there is an abundance of up-to-date overspecialized medical educational content available in individual academic institutions, such content cannot at the moment be easily discovered, retrieved, re-used and thus shared across institutions and among medical teachers and students [3], [4], [5].

An increasing number of higher academic institutions are using a variety of web-based learning management tools to support their teaching. This gained experience indicates that similar web-based tools can support and enhance educational collaboration on a permanent basis among higher education and research institutions in medicine.

Such an approach has been exploited in the IntraMEDnet[6] and WideMEDnet [7] projects, where partners from 5 universities from 3 different European countries have developed a distributed pool of specialized educational modules in state-of-the-art scientific issues related to medicine, biomedical and biological sciences. This approach expands in mEducator [8] project where 14 partners from 9 different European countries implement and critically evaluate existing standards and reference models in the field of e-learning in order to enable specialized state-of-the-art medical educational content to be discovered,
retrieved, shared and re-used across European higher academic institutions. The paper places emphasis on the development of a web-based collaborative environment to support the identification of partners’ educational needs and excellencies by means of taxonomies and educational standards, while it considers the potential of this virtual collection of educational objects to grow into an integrated distributed environment with mechanisms to automate learning module management and retrieval.

The remainder of this paper is structured as follows. In section II we provide a brief account on current trends and approaches in online Medical Education, along with the approach to web collaboration in Medicine that was followed in the IntraMEDnet and WideMEDnet projects. Section III illustrates the proposed system/framework that utilises Taxonomies and Standards in a Virtual Collaboration Environment. The following section presents a simple Scenario of use, while section V describes a prototype of the system. In the final section, a discussion on key issues of concern and future work is provided.

II. BACKGROUND INFORMATION

A. Current trends and approaches in creating online Medical educational content

During the last decades educational technology came into foreground and a multiple of institutions embarked on research related to online and distance education. Furthermore, educational standards like the Shareable Content Object Reference Model, SCORM [9] appeared. SCORM is a set of eXtensible Markup Language (XML) based specifications to define, manage, access and deliver modular educational objects so that they can be easily shared among different learning management systems. Extensions of SCORM into health/medical education provided what is known as SCORM for healthcare, or IEEE and Healthcare Learning Object Metadata [10], [11], [12].

Moreover, numerous research efforts focus on the technical side of delivering the course content and the appropriate Learning Management System preconditions and features, so as to fully exploit the prerequisites for the educational standards, when some other attempts focus on the content creation itself [13], [14], [15], [16]. In the field of Medical education supplement frameworks were proposed [17] such as the accreditation of online courses [18]. Other interesting pieces of research are those referring to authoring tools proposed or created with the aim to provide efficient ways to construct SCORM compliant courses [19].

On the other hand, models for online learning [20] and intelligent tutoring systems were proposed in order to fill the gap of the physical absence of the tutor. However, to this extent, one can note the absence of a system that would integrate traditional and contemporary educational strategies and didactic models [21] for e-learning with the automatic creation of a didactic plan in the form of a SCORM content package, containing also appropriate tips for the tutor, and allowing for a diversity of choices for educational strategies.

B. A different approach to Web Collaboration in Medicine

In general, any educational approach contains not only the availability of material to students, or simply the collaboration of teachers in developing or offering the material to students. The educational process starts with the design of the module (or course) itself, continues with the selection of teaching methods or strategies that will accommodate the design requirements, continues with the development of the content, and finishes with the evaluation (of teachers and students in general). A draft drawing containing the main features of this approach is given below.

![Figure 1. Generic steps of the educational process](image)

To facilitate medical teaching collaboration with contemporary ICT tools, one needs to fully exploit the following:

- Web Collaboration Environments for module design
- Classical web collaboration or more contemporary Web 2.0 tools (like Wikis, or Blogs) for the choice of teaching strategies
- SCORM compatible learning management systems (LMS) for structuring the course and making it available
- Multimedia Authoring tool(s) for creating (original) content
- Parts of LMS or other survey tools for online course evaluation

In the IntraMEDnet [6] and WideMEDnet [7] projects use of the above is made so as to enable the sharing of educational expertise among different medical academic institutions on all levels of education. The aim is to enable the construction of a medical educational/research intranet among the participating institutions, so as to support undergraduate educational program, post-graduate practice and residency. The teaching policy in these projects is based on developing distributed pools of individual self-contained, well described, highly specialized educational objects, each developed by the most appropriate expert in the field. At a second stage, such objects are combined to form either an instructor to form a traditional instructional educational module of high quality or are dynamically combined via a problem/case-based learning episode [22]. Both approaches are delivered via generic web-based LMS and related tools. To account for the above, the IntraMEDnet and WideMEDnet research teams have identified general educational topics of common interest, based on current educational needs of the partners’ institutions, as well as, existing expertise and excellencies within the partners. Thus, specific learning objects of interest have been identified and described in detail [19], [23]. Detailed educational object
attributes include: creator (person and institute), target institute and course, type, educational goal, target audience, educational objectives, learning outcomes, teaching methods & strategies, content outline, evaluation strategy, learning hours/workload, provision of continuous updates (life cycle information), language(s) of instruction, and bibliography.

All educational activities in the IntraMEDnet and WideMEDnet projects are deployed via open source generic learning management systems already used by the partner universities. Central to this activity is the employment of the emerging e-learning standard SCORM [9]. To accommodate the above requirements, but also automate the procedure, IntraMEDnet partners have set up a virtual collaborative space where educational needs, as well as, excellencies, are specified along taxonomies based on: (i) subject/topic specific contexts, (ii) cases or problems defined in the form of familiar learning objects and (iii) the underlying learning/educational theories [24].

III. A SYSTEM FOR USING TAXONOMIES AND STANDARDS WITHIN THE VIRTUAL COLLABORATION ENVIRONMENT

The proposed system consists of two basic modules. The first one is the web-based interface for users’ interactions, while the second one is the core system itself.

The web-based interface is responsible for the provision of the required information according to the taxonomies discussed above and presented in [24]. Furthermore, the delivery of the learning plan is provided through a web-based interface in the format of a SCORM Package.

The core system consists of four submodules: (i) the Taxonomy Analyzer, (ii) the Intelligent Decision Maker, (iii) the Administration Module and (iv) the Database and File System. The Taxonomy Analyzer is responsible for analyzing the input data received in the form of an XML file and provides the Intelligent Decision Maker with standardized indicators that are created in comparison with the user input data. The Intelligent Decision Maker decides for the appropriate SCORM package that is going to be delivered using a number of predefined algorithms taking into account the indicators received from the Taxonomy Analyzer. Last but not least, the Administration Module is responsible for retrieving the appropriate SCORM package from the Database and File System and provides it as an output to the end user (presumably a medical teacher). This module also provides teachers with various tips categorized and organized according to international didactic approaches such as the Cognitive and Affective Domain that Bloom Introduced in the famous “Bloom Taxonomy” [25]. To this extent, the Administration Module is responsible for administering user rights and enabling the collaboration between users. In the Database and File System, useful information for every stage of the implementation is being managed and a history of the creation cycle is being recorded. Figure 2 provides an overall illustration of the system.

As already mentioned above, the main roles in this system’s operational framework are those of the teacher (user) and the administrator. The “Teacher” provides all necessary data and receives the preformatted SCORM package in order to create the course. The “Administrator” role, apart from the ordinary actions (such user creation, backup of the Database and File System, etc.), is also responsible for adding or pulling out algorithms for decision making for the content and the didactic approaches and methods.

IV. SCENARIO OF USE

In a typical scenario of use, we assume two medical teachers that want to deliver an e-learning course in a Computer Room of a Clinic to a group of medical students. Let’s suppose that the content of the course is related to the “diagnosis of a heart attack from a distance”. Medical teachers provide the system with appropriate information which among others includes the communication infrastructure (xDSL 1.Mb), the delivery options (Synchronous Communication, Video), the determination of the Learning object (e.g. that is “training – oriented”), the approach type (i.e. that is “process oriented”) and the preferable didactic approach (i.e. that is “PBL or Problem Based Learning”). The teacher also provides the aimed competence degree (i.e. “Advanced Beginner”) and the delivery medium dimension (i.e. the “internet”).

The system analyzes the inserted data and transforms them into an appropriate XML file, which is processed by the Taxonomy Analyzer and provides the Intelligent

![Figure 2. The overall architecture of the system that utilises a Taxonomy and SCORM within a Virtual Collaboration Environment.](image)
Decision Maker with indicators about the previously mentioned categories. The Intelligent Decision Maker takes into account the preferable didactic approach and its suitability with the rest of the indicators and provides its decision about the SCORM content package to the Administrative Module. For instance, PBL does not come into antithesis with the delivery options of Synchronous Communication, Video, but it also needs some asynchronous modules, such as a wiki, a discussion forum and in general WEB 2.0 tools. To this extent, PBL is suitable for the advanced beginner level. Those modules are then added into the SCORM content package.

The Administration Module, based on the same indicators and on the decided SCORM content package provides useful tips that teachers should have in mind upon adding the content. Such tips may be: “Students in this level can understand information and grasp the meaning; try to make them translate knowledge into new contexts and allow them to interpret, compare and contrast facts”; “Students should be able to order, group, and infer causes and predict consequences. The teacher should give them the chance to: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch different terms/theories”. Furthermore, the module informs the tutor that the videos that he/she has selected as a delivery option should not be very large (e.g., > 5MB) because students are on simple xDSL which may not be as fast as the teacher’s internet connection.

The teachers are then ready to download both the SCORM content package in order to fill it with the course information and the tele-cardiology taxonomy XML file (Figure 3) in order to have access to their course preferences, so that time is spared next time the access the system (no need to insert all information from the beginning, but only the items requiring change).

V.Prototype Implementation

We have developed a prototype environment for telemedicine teaching collaboration using PHP on a linux server having MySQL as a database.
password login. Sessions variables ensure that no user would jump to another page viewing data or adding fake data to the environment. The second step is to determine the user permissions. Thus, authorization of the user determines the user’s role which is used to provide access to certain modules and processes of the environment. In order to account for the simplicity of the development we used as access control strategy the Role-Based Access Control (RBAC). In addition, confidentiality of data is achieved through data encryption by means of SSL/TLS protocols.

Numerous PHP pages are used for inserting data; they are provided in junks of meaningful groups of items, and they all lead to the final page showing the result with advice tips and the appropriate SCORM Package. At this level the Taxonomy Analyzer module sends all the information to the Intelligent Decision Maker which uses simple algorithms to decide about the SCORM Packages. Some initial SCORM packages for PBL and CBL (Case Based Learning) were implemented with the addition of WEB 2.0 tools (Forums, Wikis, Podcasts, Vodcasts, etc.). The Administration Module, except of the access control management, provides dynamic useful tips based on Bloom’s Taxonomy (Cognitive and Affective Domain), Benner’s degrees of competency [26], as well as, on information originating from the Taxonomy Analyzer and the Intelligent Decision Maker.

The screenshots in figure 4 illustrate this approach in the case of academic collaboration in telemedicine/telecardiology teaching.

VI. DISCUSSION AND FUTURE WORK

Although the thematic area of interest illustrated above is telemedicine (telecardiology), this is by no means exclusive of others. Current research effort is also spent on allowing for a generic taxonomy based approach that will enable pools of individual educational objects to be developed by the participating experts/partners according to their expertise. Then various real case scenarios (familiar objects) especially developed for students to follow so as to conquer the required knowledge. The proposed environment assists partners (academic teachers, experts) in designing their “common” module of interest (telemedicine in the illustrated case), but also in distributing the cases in terms of their likely association and interpretation of the complex health care environment (in order to transform the real cases into familiar learning objects), but also the learning theory they choose to follow (usually linked with the student level e.g. undergraduate etc).

To this extent, the prototype presented above needs improvements in terms of dynamic management of algorithms used by the Intelligent Decision Maker. Such improvements may account for upgraded efficiency in deciding the suitability of SCORM packages and dynamic insertions of didactic and educational theories in the form of taxonomies at the level of the Administration Module. Closely to the completion of the prototype pre-build open source modules for collaboration within teachers are going to be added.

The provision of SCORM allows for a future, easy integration of the environment with an LMS, so as to alleviate all the burdens of managing and reusing these in other contexts and within different educational modules. Furthermore, Healthcare Learning Object Metadata which are based on the IEEE LOM could be added to the system either as an input resource or as an output accompanying the SCORM Package.

The continuation of this work will be emphasized within mEducator project [8] where focus will be on implementing and comparing two alternative solutions for educational content discovery and retrieval on the web.

One of our final long term goals is to directly link this taxonomy and Standards-Based Virtual Collaboration Environment for Medical Education with another one, namely, the Accreditation System for Online Medical Education that was proposed in [18] and is currently under implementation.

Last but not least evaluation of our prototype virtual collaboration environment for sharing medical educational content is being made. Evaluation will provide early feedback concerning the integration of new functionality and possible usability problems.

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